

S. M. MAINI

-

EXPLORATIONS
IN THE PSYCHOLOGY OF
THE RESEARCH PROCESS

Revised 1981

CWK GLEERUP

STUDIA PSYCHOLOGICA ET PAEDAGOGICA
SERIES ALTERA LV

**EXPLORATIONS
IN THE PSYCHOLOGY OF
THE RESEARCH PROCESS**

S. M. Maini

CWK GLEERUP

CWK Glerup is the imprint of the scientific
and scholarly publications of LiberLäromedel Lund

To

My mother



© 1981 S.M. Maini
ISBN 91-40-04780-6
ISSN 0346-5926

Printed in Sweden, Infotryck ab, Malmö 1981.187

Acknowledgements

My interest in the present field of study was awakened by my supervisor and later on my colleague - Dr. Bertil Nordbeck. Thanks are due to him for putting me on the trail of research that was new, exciting and challenging. My supervisor and scientific mentor, Professor Gudmund Smith, has influenced my thinking in subtle ways, and without him this dissertation would not have been possible.

Many others have been helpful, critical and questioning. To name some and forget others would not be right. So, thanks to all who had the patience to engage with me not only in dialogues but also "duologues".

Drs. Nilsson and Westerlundh for thorough and constructive criticism on various aspects of the reports (i.e. "reconstructed logic"), and acting Professor Rydén for comments and suggestions.

Mrs. B. Hommerberg is thanked most graciously for her efficient typing but more important her tolerance and ability in deciphering my drafts.

Valdimar Briem, M.Sc. is cordially thanked for polishing and improving the English.

And finally, as the reports show, research ventures into the sphere of family life, and as proof gratitude is expressed for their understanding and encouragement to my spouse and companion Avinash, my father and my children Kiran, Radha and Sujata.

Grants for the studies during the past 10 year period have been received from the Tricentennial Fund of the State Bank of Sweden, Council for Social Science Research, University of Lund for the doctoral stipendium and the departments of Psychology and Research Policy Programme for their facilities.

Last, but not least, the subjects, both students and researchers, who had the patience and openness to divulge some of their "secrets".

"The scientific creator, like every other, is apt to be inspired by passions to which he gives an intellectualistic expression amounting to an undemonstrated faith, without which he would probably achieve little".

Bertrand Russell

The present dissertation is based on the following five reports, referred to in the text by the respective Roman numerals.

- I. Nordbeck, B. & Maini, S.M. Critical moments and processes in research work. Psychological Research Bulletin, 1970, Lund University, Sweden, 10, No. 11.
- II. Maini, S.M. & Nordbeck, B. Critical moments in research work. A study of research workers in the Behavioural Sciences Psychological Research Bulletin, 1972, Lund University, Sweden, 12, No. 10.
- III. Maini, S.M. and Nordbeck, B. Critical moments, the creative process and research motivation. International Social Science Journal, 1973, XXV, No. 1/2, 190-204.
- IV. Maini, S.M. Personality and cognitive differences between an original and a non-original group. Perceptual and Motor Skills, 1973, 37, 555-563.
- V. Maini, S.M. Cognitive restructuring in a problem solving situation as reflected in the level of activity and the Gestalt Completion Test. Psychological Research Bulletin, 1981, Lund University, Sweden, 13, No. 3 (in press).

Introduction

During the past two to three decades there has been a tremendous increase in interest in the activities of scientists¹ due to, among other things, political, economic and military interests in the exploitation of scientific discoveries. Earlier, the role and function of science was also discussed (e.g. Russell, 1952) but the increased interest during the recent years is witnessed by the appearance of studies which can be subsumed under the broad title of "Science of Science". The sub-disciplines are: Philosophy of Science (e.g. Popper, 1959; Kuhn, 1962; Madsen, 1968), History of Science (e.g. Knight, 1976), Sociology of Science (Merton, 1957; Brante, 1980), and Psychology of Science (e.g. Maslow, 1966; Singer, 1971; Rothenburg, 1979). All these disciplines have examined science with their respective microscopes and come to varying conclusions. The interest within psychology has been devoted to such aspects as creativity in the sciences, research as a form of cognition, selection and recruitment of scientists, and studies of eminent scientists.

Few studies have actually looked at how scientists go about their work, i.e. looked into the scientific workshop. Kaplan (1964) makes a most fitting distinction between what is reported and what is actually done by scientists. He refers to the former as "reconstructed logic" and the latter as "logic-in-process". The rational construction is characterized by the "hypothetico-deductive method" and is, among other things, an idealization of scientific practice. This tells us how the scientist ought to think but little about the actual drama of the logic-in-process, i.e. how the scientist actually thinks. It can be stated that the reconstructed logic is not only the face presented to the public but also the actual model that the scientific community attempts to impress upon the potential scientist during his/her socialization in the rituals of research.

Psychology of Science

The distinction between the two types of logic leads us into the

¹ It is interesting to note that the term "scientist" was coined in the 1830s. Europeans took the lead in many of the sciences in the late 17th century prior to which the Chinese, Arabs and Greeks had dominated the scene (Knight, 1976; Russell, 1952). In the present paper the words "scientist" and "researcher" are used interchangeably and refer primarily to persons conducting research in university settings.

field of "Psychology of Science". In this relatively new field, autobiographical contributions by scientists present the intellectual history of ideas (e.g. Poincaré, 1924; Watson, 1968). Biographies (Ghiselin, 1963) and studies of eminent scholars (Maslow, 1966, 1967) have been done which purport to reveal the makings of a genius (e.g. Albert, 1975). The psychological functioning of the creative scientist has been studied by various techniques (e.g. Patrick, 1938; Barron, 1968, 1969; Roe, 1953; Smith & Danielsson, 1978; Szekely, 1976). A considerable amount of research was done in the field of creativity after the famous address on creativity to the American Psychological Association by Guilford (1950). Albert (1969) has analyzed the role of this address and, among other factors, he mentions the placing of the Sputnik by the USSR in orbit around the earth as contributing to the accelerated interest in the field of creativity generally and specifically in the sciences. This emphasises not only the interdependence of science and society but also that science is as much an expression of a culture in a certain time and place as it is a knowledge-gathering process. That the interest has not only centered on the scientist and other creative professions (e.g. the Arts) is witnessed by the studies in the development of creativity in the school and the childhood of famous and creative scientists and researchers (e.g. Torrance, 1964; Gowan, 1972; Getzels & Jackson, 1962; Jablonski, 1964; Taylor, 1964). Within psychoanalysis this area has been the object of considerable interest. Creativity, in particular that of the scientist, has been discussed in several symposia and journal articles (e.g. Giovacchini, 1960, 1965; Kanzer, 1955; Kubie, 1958; Kris, 1964), even though Freud himself found the phenomena of creativity elusive. Attempts to study the scientist at work and to define a creative research environment have also been areas of concern (e.g. Pelz & Andrews, 1966). Some of the other aspects of this area that have been investigated are age and achievement in science (Lehman, 1960; Dennis, 1958), studies of Nobel Laureates (Zuckerman, 1967), rules and norms of science (Merton, 1957), and research teams and their productivity and efficiency (Jense, 1979; Stankiewicz, 1980).

Even though some contributions, e.g. autobiographical reports by eminent scientists have provided some interesting insights into the research process, most of the studies of creativity and related areas have not had the actual research process as their main theme.

But it is obvious that creativity does not exist in vacuo, but is only interpretable in the light of and as an aspect of the activity in which it appears. Therefore, what is needed before one can give an account of the nature of scientific creativity is a thorough study of how scientists work, how they direct their process of inquiry, and what they feel are the critical moments in their research. To this end a project was started (Nordbeck, 1968) to study the psychology of the researcher and research. The aim of the project was to study the research process and the researcher, in particular the emergence of new ideas and "creativity", as well as research education and problem-solving¹. The present dissertation is based on a series of studies which came about as a result of the project mentioned above, and is an attempt to investigate the psychology of science and the scientist with respect to logic-in-process. It includes the initial empirical descriptive studies of critical moments in the process of research, motivation for research, phases in the creative process and further studies in creativity and problem-solving.

A note on method

The exploratory and descriptive studies (I-III, cf. above) were designed to investigate what had previously only been guessed at or reported in anecdotes and biographies. This means that the knowledge generated here is partly descriptive. It is hoped that further studies will contribute more definitive data as they would constitute cross-validations in different populations. The techniques of data collection have been analyses of biographical reports, interviews, half-structured questionnaires, and psychometric methods.

Statistical tests have only been used where their applicability was called for by the nature of the data. Otherwise the analysis has been in the form of systematization through categorization as, for example, in the studies of critical moments. Thus, a whole range of techniques have been used, where the principal guideline was the area of exploration. In this way, both "soft" and "hard" data have been collected, depending upon the strictness of the problem formulations, ranging from explorations in the research process to studies of problem-solving in the laboratory.

¹ The concept of "re-search" is a misnomer as it is not only re-search but also search that scientists indulge in.

A summary of the reports

Study I describes, firstly, the state of knowledge in the area, and, secondly, the research programme embarked upon in order to increase this knowledge. These are considered in turn.

Generally speaking the research process is initiated by the identification and formulation of a problem. Thus, it connotes something that is prescientific, but this component of the process is always followed by a more careful, patient, systematic and laborious research activity aimed at solving the problem, and, thereby, contributing to scientific knowledge. During this diligent inquiry there are certain individual and environmental factors that direct the process and remind us of the "humaneness" of the scientific endeavour. The original problems and/or ideas that emerge during the various stages in the research process lead us to discuss the creative process and other critical moments in the research process. Some of the critical moments related to the initiation of and changes in the course of the individuals' research are, a) observing a problem, receiving a problem from the supervisor (in the case of the research student), and coming into contact with the aspired area of research; b) interruption of work in a field of study, temporary or permanent, because of lack of time and/or criticism; c) difficulties in restricting or formulating a clear and concise problem; and d) informal communication.

Situations when new and important ideas and insights emerge are also frequently reported as critical moments. The decisive ideas emerge: a) when one is relatively conversant with the problem area; b) in connection with problem-identification and final integration and analysis of data; c) when the researcher is concentrating upon something else than, but often something related to the problem or some aspect pertaining to the idea; and d) after periods of low activity of varying durations triggered by a sense of failure or general uneasiness.

Study II was based on a questionnaire and a follow-up interview restricted to moments which the subjects (behavioural scientists) experienced as having had direct relevance for the course, development and results of their work. Ten of the 28 subjects were post-doctoral research workers and the rest were doctoral students (referred to in the dissertation as potential researchers). From their responses, critical moments were broadly classified according to their positive

and negative contents into two major categories, the motivational and the cognitive, which were then sub-divided further into interpersonal situations, research ideas and time.

One of the aims of the study was to compare the results with a previous study of natural scientists (Nordbeck, 1969), in which partly different data collection techniques (half-structured interviews) were used. The results point to a considerable consistency in the characteristics of the critical moments among researchers from the two disciplines. These similarities refer especially to the positive moments and concern, for example, the importance of situations pertaining to identification and selection of problems, informal communications, and the emergence of new ideas. In both studies there was also a high frequency of negative moments pertaining to, e.g. research supervision and research motivation. It was also noted that (a) most critical moments occurred during the initial stages of the educational and research process, (b) the precursors of the critical new ideas were negative experiences and direct informal contacts. The differences between the natural science researchers of the previous study and the behavioural researchers investigated here came about mostly with regard to the negative moments, i.e. the natural scientists reported more often moments pertaining to time and to difficulties connected with materials and apparatus while "critique" situations were more frequent among the behavioural researchers. The study also reports upon and discusses different approaches to the collection and processing of data.

Study III summarizes the results of 1) study II above, 2) a study of biologists using a semi-structured interview (Nordbeck, 1972), and 3) the analysis of autobiographical data from an international and inter-disciplinary group of scientists (Maini, 1971). The data from the autobiographical study supplements the former two as they derive from an independent source (Dalenius, et al., 1970). The empirical studies have as their subjects "ordinary" researchers while the autobiographies are by "eminent" scientists. The use of historical, autobiographical, and published data is often wrought with problems as the authors are often tempted to rewrite their own history, forget, and perhaps also to put forth the "ideal" picture of science (see introduction) to the readers. But despite the shortcomings, this "historical approach" was interesting as a complement to our own empirical studies. The three main areas discussed are critical moments,

the creative process and research motivation.

The results from the autobiographical study show remarkable similarities to the data summarized above (study II) with respect to critical moments and the creative process. Apart from the similarities, some further results point to a relationship between critical moments and research experience. The subjects were divided into two groups, an older group with research experience exceeding six years and a younger one, both in age and experience. The former more frequently reported moments that could be traced to their ontogenesis, e.g. experiences from the primary school days which more or less decided their field of research. They also reported moments pertaining to the desire for peace and solitude and the reading of literature and dissertations as the source of ideas and stimulation.

The motivation for research can be subsumed under the title of "intellectual stimulation". It includes not only the desire for solving problems but also the "naive" asking of questions which constantly uncover problems that need solving. The second most frequently mentioned motivational factor is the desire for an "original contribution". Other factors in descending order of importance are: recognition by the scientific community and esteemed peers, practical applications of contributions to science, and financial gain.

Study IV. As mentioned in the introduction the purpose of the studies was to explore the research process and related areas. The introductory, descriptive studies led to the creation, for the purposes of a formal study, of situations which were analogous to particular aspects of the research process. Thus, in study IV an attempt was made to try out the usefulness of certain cognitive and personality test-instruments, viz. the Gestalt Completion Test (GCT) and the Opinions, Attitudes and Personality (OAP) inventory, on a group of students prior to their use with researchers. In this study, an "original" and a "non-original" group is chosen on the basis of two originality measures extracted from the Utility Test and the GCT. The original group, when compared with the non-original, was more fluent, less rigid and less stimulus-bound. This group also showed itself to be Tolerant of Ambiguity, low on Social Desirability and capable of adaptive Regression in the Service of the Ego. The results are discussed in terms of an Objective-Subjective continuum: Subjects at the objective pole are more stimulus bound, rigid and

lacking in adaptive regression. The original group is more proximal to the subjective end of the continuum and have the ability to suspend convergent or logical considerations temporarily and thus facilitate "subjective", novel and unorthodox thinking.

Study V was carried out in order to test the validity of one of the formulations of the creative process proposed in Study I, i.e. viewing research as a succession of problem solving endeavours. Study V contains a report of a pilot investigation, preliminary to the choice of a "suitable and relevant" problem, and three subsequent experiments where the chosen problem was used to test problem-solving ability: Experiment 1, with male students, experiment 2, with female students, and experiment 3, with a group of natural scientists. The problem - The Hatrack problem - requires the subject to make a structure sufficiently stable to support the weight of a heavy overcoat, using only two sticks (of given length) and an adjustable C-clamp. The hatrack is to be built in the center of the room - marked by a cross in the experiments.

The first experiment revealed that the personality inventory (OAP) did not show any significant relationships with the problem-solving task and consequently this test was dropped from the next two experiments. The results of the three experiments show that success in the solution of the problem is related to the level of active investigatory behaviour involving all the stimulus material available to the subjects. The cognitive test (GCT) provided some interesting and consistent results, viz. that non-solvers tend to give regressive responses on the GCT, while the solvers retain a balance between stimulus-bound (objective) and stimulus-free (subjective) responses in the GCT (see the reference to the Subjective-Objective continuum above). In the third study, certain conclusions are drawn about the similarities between the experimental problem and phases in the research process as reported by researchers in an interview. These phases are apparatus construction field work, and experimental laboratory work.

Some theoretical issues

One of the principal aims of the "Psychology of Science" can be stated as being the study and accurate analysis of the development of knowledge as reflected in scientists' actual research process. (cf. Mussachia, 1979). This leads us to the question of how knowledge is acquired and generated. Piaget (1972) states that "knowledge is never in a state and

always forms a process, this process is essentially the passage of a lesser to a greater validity" (p. 7). In viewing knowledge as a process we are also admitting that we do not ever know when we have complete knowledge. It is in fact a question of being sensitive to new problems without knowing where we are going to end up, i.e. constant interactions between the individual (subject) and his environment (the object). Piaget takes examples from developmental psychology, e.g. the child's development of the conception of space, number, and permanence of objects, to show the fruitfulness of his approach to link child development with epistemology. His position is that if one studies only one level of development, e.g. that of the adult, then it is easy to distinguish the problems of intelligence and its functions and the emotions, on the one hand, from the broad problems of knowledge (epistemology), on the other. But if we study cognitive functions from a developmental point of view and thus the formation and transformation of human intelligence, then the problems are formulated in terms of: How is knowledge acquired, how does it increase and how does it become organized and reorganized? (Piaget, 1978). This is the view adopted in this thesis. The logic-in-process in the adult researcher can be better understood by partaking of developmental psychology and linking it, in an analogous manner, to the actual knowledge-gathering process of the researcher.

But it is not sufficient to take the above as a basis for the following pages. The frame of reference has to be supplemented by including the role of socialization in the development of individuals' intelligence (intelligence being the basic structural given wherein knowledge is developed). And if socialization is given this importance then communication (cf. Israel, 1980) is the means of thought organization (Rapaport, 1951). From this it follows that interpersonal relationships in general contribute to the development of human thinking. The foregoing focuses upon the ontogenesis of intelligence and implies that intellectual development goes hand in hand with socio-emotional development. From this it follows that in the adult researcher we should also consider the dialectic nature of the intellectual and the socio-emotional, e.g. that interpersonal relationships (i.e. socialization and the assimilation of the scientific modes of communication) in general and more specifically in the research process contribute to the development of scientific thinking.

The basic concepts (to be elaborated upon below) that are relevant for the present purposes and form an intrinsic part in the above view of knowledge are adaptation, assimilation, accomodation, and equilibrium. These Piagetian concepts form the pillars of the intellectual development (cf. Sacks, 1979) of the individual, both ontogenetically and in the actual knowledge gathering process of the researcher.

Having set the scenario from child development in a Piagetian spirit, and indicated its relevance (analogously) for studying and understanding the adult scientist's knowledge-gathering process through this perspective, it is appropriate to try and fit the results of the present studies into it.

We consider intelligence, knowledge, problem-solving and creativity as four concepts important in considering the actual research process and suggest that the concept of intelligence is paramount, in the sense that it is all-pervading. The research process reveals the scientist's attempts at cognitive adaptation (cf. Piaget, 1967; Nilsson, 1980) through the twin processes of assimilation and accomodation and the equilibria arrived at successively in the interplay of these processes. The implication of this ontogenetical perspective, both generally and specifically for the individual, is that knowledge represents the "established and consensual", while one form of problem-solving is the "reorganized and restructured" exploitation of knowledge (cf. Kuhn's (1970) reference to puzzle-solving during periods of "normal science"), and that creativity produces "new" knowledge (cf. Kuhn's reference to periods of "extraordinary science" and paradigm-shifts). Finally, intelligence (a necessary but not sufficient factor) has the unique role of revealing itself in all the activities distinguished above (cf. studies of the relationship between intelligence and creativity, Getzels & Jackson, 1962; Guilford, 1967, Jeffmar, 1978). Concomitantly with the adaptations in the above conceptualisation, we also include the socio-emotional development of the individual researcher, i.e. the socialization of the researcher in the rigours, norms and values of science.

The initial distinction between the two forms of logic is supported by the empirical findings of our studies. Furthermore, logic-in-process reveals the researchers' constant attempts at solving problems,

gathering data, interpreting results etc. These activities are cognitive adaptations involving both assimilatory and accomodatory activities with varying degrees of dominance.

The critical moments reveal the researchers' attempts at mastering situations both at a cognitive and a motivational level. The cognitive moments generally refer to progress in the form of the emergence of ideas, seeing results and cognitive stagnation. The motivational component is often difficult to isolate as it is entwined in the cognitive, but it is revealed in the emotional reactions of the individual.

The motivation for research is generally referred to as intellectual stimulation and the need for variety by our subjects. This comes close to Piaget's equilibration model of intellectual development, wherein motivation is considered as an inherent "need to know". This "need to know" is reminiscent of conceptions of learning and personality theories which stress the importance of curiosity and novelty or exploratory drives. But the point here is that the "need to cognize is contained in and is almost synonymous with intellectual activity itself, an assimilatory activity whose essential nature it is to function". (Flavell, 1963, p. 80). Bearing in mind the frustrating experiences that some of the researchers reported, it is valid to conclude that this "need" helps the researcher to overcome the negative experiences and periods of stagnation and motivates him to reach out into the environment again and again until a satisfactory solution has been arrived at, i.e. cognitive adaptation. To arrive at "deeper" and more idiosyncratic motivational factors in the psychoanalytic sense, e.g. those pertaining to repressed motivations and their vicissitudes, one has to look for empirical data from the clinical field (cf. the project started in Lund entitled "Conversations with Researchers", where therapeutic techniques are used to help researchers to overcome blocks in their actual research process and creativity. (Maini, et al., 1980). One can agree with Kessen (1971) that the two theories of motivation (Piagetian and Freudian), the "cold" and the "hot", together can provide a differentiated view of motivation in the research enterprise.

In the frame of reference adopted above, one form of problem-solving (the reference to "one form of problem-solving" will become clear below) was referred to as "reorganized and restructured" knowledge. In

the last study (V) the aim was to study the problem-solving aspects of the research process. This problem-solving view of the research process has a certain face validity but it is difficult to reproduce or replicate it in the laboratory. All one can do is come as close to the phenomena as possible. A certain discrepancy is bound to exist between the laboratory and actual scientific thinking. The reason is that the subject in the experimental situation knows that a problem exists and that it has an answer. In research, the problem identification and formulation part (see the results of the critical moment studies) is cognized by the subject and, depending upon the stringency of problem formulation, there may or may not be a solution. Perhaps the ability to formulate good questions may be different from the ability to solve problems. The former relies more on intuition while the latter may be considered more rational in nature (see Wason, 1966).

In study V a problem was chosen which was considered to approximate some parts of the research process, e.g. apparatus construction and field problems. During the actual solving of the problem the subjects (both students and researchers) often went back to solutions that were already rejected by the subjects themselves. This raises, at a general level, the question of the criteria of falsification as put forth by Popper (1959). It seems that the subjects were not prepared to falsify their hypothesis, on the contrary their aim seemed to be to confirm their hypothesis. Wason (1960) reports similar results with other problems. It could be hypothesized that the main attempts in the problem-solving task were at assimilation and only a few succeeded in the restructuring of their cognitive schemas, i.e. accomodation.

This brings us to the question of the relationship between problem-solving and creativity. Creativity remains an elusive concept even though various related variables, personality, childhood etc have been studied and some consensus exists as to, e.g., the phases in the creative process, and other related issues. One solution to the dilemma of creativity in the present context is to consider it as a form of problem-solving and distinguish between productive and re-productive problem-solving or thinking. According to Szekely (1976b) the criterion for reproductive thinking would be that the solution to a particular problem consists of a more or less intense modification of an earlier experience (e.g. the Pea problem in study V) or an

earlier problem situation. Productive thinking, on the other hand, constitutes a completely new solution, a creation, which is not similar to earlier problem solutions or experiences. Raaheim (1974) distinguishes between problem-solving requiring the restructuring of a familiar pattern and the hatrack situation which demands the creation of a new structure. The former comes close to reproductive while the latter reminds of productive problem-solving. In the problem used in the laboratory experiment (the hatrack problem) the need was for productive thinking, i.e. reorganization and restructuring. This distinction solves the problem partly, but not wholly. It would be appropriate to reserve the terms creativity and creative problem-solving for epoch making contributions, e.g. the different "centrisms" challenged by Copernicus (geocentrism), Darwin (homocentrism) and Freud (adultocentrism) (cf. Breger, 1974). These are generally known after the fact, and it often takes centuries or decades before they are accepted. There are apparent exceptions, e.g. Watson & Crick who broke the genetic code and gained immediate recognition. Only history will show if this was an epoch making discovery. (cf. Taylors (1959) distinction between different levels of creativity, and Ekvalls (1979) discussion of creativity and problem-solving).

Finally, socialization in the ways of scientific thinking is an area that has been indicated in our studies by the importance given to the supervisor, the crucial role of inter-personal situations, informal contacts, and problems in connection with writing reports, i.e. in the language of the sciences - reconstructed logic. It seems that here one can distinguish and speculate over three spheres - the intellectual, the emotional, and the ideological. The intellectual development and training is in systematic thinking, setting-up of hypotheses, and following the maxims of science. The emotional sphere is revealed in the discrepancy experienced between, e.g. the reconstructed logic and logic-in-process, and sensitivity to "critique" situations involving one's ideas and reports. The ideological part is revealed in the internalization of the values of the scientific community, maintaining its norms and emphases on individual autonomy and freedom. The socialization in the ways of the sciences is generally carried out both through passive and active processes. The latter are, for example, explicit instruction during supervision, recognition and awards or grants. The former has as its major mechanisms identification and internalization, the objects of such processes being the supervisor, the professor, or some eminent scientist. One is reminded of the social-

ization process that a child goes through and the similarities in the mechanisms and processes involved - in child development and the potential scientist's development. This similarity further underscores the conceptual frame of reference adopted in this summary.

Some implications and a look to the future

Scientific work, as revealed in the logic-in-process, is an extremely taxing enterprise, interspersed with the emergence of ideas, both ordinary run-of-the-mill type and awe inspiring insights. The basic ingredients are a form of passionate commitment, avoiding early closure, flexibility, ability to pursue ideas and tolerance of anxiety. An example here is the role of anxiety (Smith & Carlsson, 1981), both "benign" and "malignant", in the creativity of the researcher. The latter leads to blocks while the former seems to be an integrated and necessary part of research and creativity.

The implications of our studies are also partly applicable for research in education (e.g. Maini, 1973; Nordbeck, 1973, 1978). Just to give an example: The results point to the crucial role of the supervisor and informal contacts not only for the research process in general but also for the generation of new ideas. Because of the importance of research in post-graduate education the supervisor-supervisee relationship should be based on mutual respect, trust and psychological security. The supervisor has to perform the role of a critic, an "inspired listener" (Szekely, 1976) and a catalyst. This can only be possible if the supervisory interactions result in developing an attitude reminiscent of "basic trust" (cf. Erikson, 1963) in the supervisee. With such an attitude and atmosphere we would not only produce "good" scientists but also reduce the drop-out rate and thus avoid a disgruntled, disenchanted and frustrated group. At a national or global level the savings would be tremendous.

Periods of stagnation, difficulties in report writing etc. are common events in the research process of both the established and the potential researcher. It ought to be accepted not only by the individual researcher but also, and especially, by the scientific community, that such problems belong to the "everyday pathology" of science. Kubie (1962) distinguishes between "overt" and "masked" neurotic symptoms. The former are, e.g. depressions, phobias and anxieties. The latter are revealed in the way the individual works, loves, plays etc., and the person is rarely aware of them or of their influence. In research

both types exist and the impression is that scientists, by virtue of, e.g. their methodology, can "mask" their neurotic symptoms and thus block or distort creativity. Therapeutic contacts (as mentioned earlier) can be helpful in alleviating the more pronounced and prolonged stoppages in the process of research. Such contacts would not only bring us closer to an understanding of the "inner logic" of the creative process and blocks to it but also help in facilitating that which human beings have always indulged in, namely: to carry on creating and gathering knowledge because they cannot help it!

References

- Albert, R.S. Genius: Present-day status of the concept and its implications for the study of creativity and giftedness. American Psychologist, 1969, 43, 743-52.
- Albert, R.S. Towards a behavioural definition of genius. American Psychologist, 1975, 30, 140-51.
- Barron, F. Creative person and creative process. New York: Holt, Rinehart & Winston, 1969.
- Barron, F. Creativity and personal freedom. New Jersey: D. Van Nostrand Co., 1968.
- Brante, T. Vetenskapens struktur och förändring. Lund: Doxa Press, 1980.
- Breger, L. From instinct to identity. The development of personality. New Jersey: Prentice-Hall, 1974.
- Dalenius, T., Karlsson, G., & Malmquist, S. Scientists at work: Festschrift in honour of Herman Wold. Stockholm: Almqvist & Wiksell, 1970.
- Dennis, W. The age decrement in outstanding scientific contributions: Fact or artifact? American Psychologist, 1958, 13, 457-60.
- Ekvall, G. Kreativitet och kreativ problemlösning. Uddevalla: Bohuslänningens AB, 1979.
- Erikson, E.H. Childhood and society. New York: Norton, 1950.
- Flavell, J.H. The developmental psychology of Jean Piaget. New York: Van Nostrand Reinhold, 1963.
- Getzels, J.W. & Jackson, P.W. Creativity and intelligence: explorations with gifted children. New York: Wiley, 1962.
- Ghiselin, B. (ed.). The creative process. New York: Mentor Books, 1963.
- Giovacchini, P.L. On scientific creativity. J. of the American Psychoanalytic Association, 1960, VIII, 407-26.
- Giovacchini, P.L. Some aspects of the development of the ego ideal of a creative scientist. Psychoanalytic Quarterly, 1965, 79-101.
- Gowan, J.C. Development of the creative individual. San Diego: Robert R. Knapp, 1972.
- Guilford, J.P. Creativity. American Psychologist, 1950, 5, 444-54.
- Guilford, J.P. The nature of human intelligence. New York: McGraw Hill, 1967.
- Israel, J. The language of dialectics and the dialectics of language. Copenhagen: Munksgaard, 1979.

- Jablonski, J.R. Developing creative research performance in public school children. In Taylor, C.W. (ed.). Widening horizons in creativity. New York: Wiley, 1964, 203-19.
- Jeffmar, M. Ways of cognitive action. Lund: Studentlitteratur, 1978.
- Jense, G. The Swedish academic market place. Lund: Studentlitteratur, 1979.
- Kanzer, M. The reality testing of the scientist. Psychoanalytic Review, 1955, 42, 412-19.
- Kaplan, A. The conduct of inquiry. Scranton: Chandler Publishing House, 1964.
- Kessen, W. Early cognitive development: Hot or cold? In Mischel, T. (ed.). Cognitive development and epistemology. New York: Academic Press, 1971, 288-309.
- Knight, D. The nature of science. London: André Deutsch, 1976.
- Kris, E. Psychoanalytic explorations in art. New York: Schocken, 1964.
- Kubie, L.S. Neurotic distortion of the creative process. Toronto: Ambassador Books, 1958.
- Kubie, L.S. The fostering of creative scientific productivity. Daedalus, 1962, XCI, 294-309.
- Kuhn, T.S. The structure of scientific revolutions. Chicago: University of Chicago Press, 1962.
- Kuhn, T.S. Logic of discovery or Psychology of research. In Lakatos, I. & Musgrave, A. (eds.). Criticism and the growth of knowledge. Cambridge: Cambridge University Press, 1970, 1-23.
- Lehman, H.C. The age decrement in outstanding scientific creativity. American Psychologist, 1960, 15, 128-34.
- Madsen, K.B. Integration through meta-science. Contribution to a symposium at the XIV International Congress of Philosophy, Vienna, September, 1968.
- Maini, S.M. Creative and critical moments and processes as reported by a group of scientists at work. 1971. Lund: Department of Psychology, (mimeo)
- Maini, S.M. A selective and annotated bibliography on post-graduate education. In Högre utbildning och forskning, UKÄ, 1973, Stockholm, Rapport nr 1. UKÄ:s rapportserie.
- Maini, S.M. et al. The role of therapy in creative functioning - a study of researchers. Current research at the Department of Psychology. Lund University I/1980.

Maslow, A.H. The psychology of science: A reconnaissance.

New York: Harper & Row, 1966.

Maslow, A.H. The creative attitude, In Mooney, R. & Razik, T.

Explorations in creativity. New York: Harper & Row, 1967,
43-54.

Merton, R.K. Priorities in scientific discovery: A chapter in the
sociology of science. American Sociological Review, 1957, 22,
635-59.

Mussachia, M. Jean Piaget and the foundations of genetic epistemo-
logy. Department of Theory of Science, University of Gothen-
burg, report no. 108, 1979.

Nilsson, A. The mechanisms of defence within a genetic-hierarchical
frame of reference. 1980, Lund University, Department of Applied
Psychology.

Nordbeck, B. Studies of psychological factors in research work and
the process of selection of researchers from among students at
universities in Sweden. 1968, Lund University, Department of
Psychology, (mimeo, summary).

Nordbeck, B. Forskaren och forskningens psykologi. Sammanfattning
av gjorda och planerade studier. 1969, Lund University, Depart-
ment of Psychology. (mimeo).

Nordbeck, B. Critical moments and the choice of problems in research
work. A study of scientists in biology. 1972, Lund University,
Department of Psychology. (mimeo) (see also critical factors in
research work. The committee on Research Economics, Stockholm,
1975, Report 7.)

Nordbeck, B. Forskarutbildning: Diskussion av några praktiska impli-
kationer på grundval av empiriska studier av doktoranders forsk-
ningsarbete. (Revised report in English: A few general problems
concerning research education.) In Högre Utbildning och forskning,
UKÄ. 1973, Stockholm. Rapport nr. 1, UKÄ:s rapportserie.

Nordbeck, B. Forskningspsykologi i teori och praktik. In Bärmark, J.
(Ed.). Forskning om forskning. Ett symposium. Göteborg, 17-18 nov.
1976. Department of Theory of Science, University of Gothenburg,
report No. 96, 1978.

Patrick, C. Scientific thought. Journal of Psychology, 1938, 5,
55-83.

Pelz, D. & Andrews, F.M. Scientists in organizations. New York:
Wiley, 1966.

- Piaget, J. Biology and knowledge. An essay on the relations between organic regulations and cognitive processes. Edinburgh: Edinburgh University Press, 1967.
- Piaget, J. Psychology and epistemology. Towards a theory of knowledge. New York: Viking Press, 1972.
- Piaget, J. What is psychology. American Psychologist, 1978, 33, 648-52.
- Poincaré, H. (1924). Mathematical creation. In Vernon, P.E. (ed.). Creativity. London: Penguin Books, 1970, 77-88.
- Popper, K.R. The logic of scientific discovery. London: Hutchinson & Co., 1959.
- Raaheim, K. Problem solving and intelligence. Bergen: Universitetsforlaget, 1974.
- Rapaport, D. Toward a theory of thinking. In Rapaport, D. (ed.). Organization and pathology of thought. New York: Columbia University Press, 1951.
- Roe, A. The making of a scientist. New York: Dodd, Mead, 1953.
- Rothenburg, A. The emerging goddess. Chicago: University of Chicago Press, 1979.
- Russel, B. The impact of science on society. London: George Allen & Unwin Ltd., 1952.
- Russel, B. Sceptical essays. London: George Allen & Unwin Ltd., 1935.
- Sacks, J.G. Dissertation work as a programme of cognitive development: A Piagetian view. 7th Annual conference on Piagetian Theory and the helping professions. 1979. University of Southern California.
- Singer, B.F. Toward a psychology of science. American Psychologist, 1971, 26, 1010-1015.
- Smith, G.J.W. & Danielsson, A. Richness in ideas, ego-involvement and efficiency in a group of scientists and humanists. A study in creativity using a process-oriented technique. Psychological Research Bulletin, Lund University, 1978, 18, No. 4-5.
- Smith, G.J.W. & Carlsson, I. Creativity and anxiety: An experimental study with psychiatric patients. (in press).
- Stankiewicz, R. Organization and the effectiveness of academic research groups. 1980, Lund University, Research Policy Institute.
- Szekely, L. A psychoanalytic study of scientific thinking. In Szekely, L. Denkverlauf, Einsamkeit und Angst. Bern: Huber, 1976, 170-271.
- Szekely, L. Productive processes in learning and thinking. See Szekely, above, 99-118. (b)

- Taylor, I.A. The nature of the creative process. In Smith, P. (ed.). Creativity. An examination of the creative process. New York: Hastings, 1959, 51-82.
- Taylor, C.W. (Ed.). Creativity: Progress and potential. New York: McGraw Hill, 1964.
- Torrance, E.P. Guiding creative talent. New Jersey: Prentice Hall, 1964.
- Wason, P.C. Reasoning. In Foss, B.M. (ed.). New horizons in Psychology 1. London: Penguin Books, 1966, 135-51.
- Wason, P.C. On the failure to eliminate hypotheses in a conceptual task. The Quarterly Journal of Experimental Psychology, 1960, XII, 129-40.
- Watson, J.D. The double helix. A personal account of the discovery of DNA. London: Weidenfeld & Nicholson, 1968.
- Zuckerman, H. Nobel laureates in science: Patterns of productivity, collaboration and authorship. American Sociological Review, 1967, 32.

A b s t r a c t. - This is a progress report from a project in the field of "Psychology of the researcher and research", which is divided into two parts. The present report, Part I, takes up some principal aspects of the individual research process and includes a summary of the theoretical background, objectives and results regarding studies of critical moments in research work, primarily among young researchers in the natural and social sciences. Specially described are critical moments and processes related to: a. Initiation of and changes in the course of research., b. The emergence of new research ideas.¹

It is remarkable that we know so little about how scientific knowledge is produced, in spite of the fact that most of us would agree about the importance of research for society as a whole as well as the private individual. Interest in this relatively new field, as much as in many other fields, has however increased during recent years. But there remain several problems which have either been neglected or received little scientific attention. Theory construction in the area of "researcher and research psychology" has not yet reached

¹Financial support for the project and the various investigations reported upon has been received from: the Tri-Centennial Fund of the Bank of Sweden and the Swedish Social Science Research Council. The investigations were carried-out at the Department of Psychology, and Research Policy Programme, University of Lund, Lund, Sweden.

the desired level of sophistication and the empirical bases of the existing theoretical endeavours are often inadequate. The shortcomings are partly due to the difficulties inherent in the data collected through "field" studies of the research process and research work. Such empirical data are often, e.g. incomplete and difficult to interpret. At this juncture in the development of this area it is imperative that more studies involving detailed qualitative analysis are carried out. Such an approach will facilitate the application of more traditional quantitative methods and analysis, and the conducting of studies with larger samples. Another method of reducing the multifarious nature of the data and gaining insight into the rather inaccessible processes involved, is to carry out experimental studies parallel to the direct studies of research situations.

The project objectives are primarily to gather empirically based knowledge for the description and theoretical development of crucial aspects of the research process, and the research work (part I), and secondarily the selection of researchers (part II, Nordbeck & Maini, 1970). Basic research is the principal characteristic of the project, but to some extent, the investigations have been so designed that information of a more practical nature could be gathered regarding the recruitment, education, and environment of the researcher.. Our studies have been concentrated upon a few problems where the need of theory construction and empirical data is the greatest. As the specific research fields in which we are working are relatively little studied, our investigations often have both an exploratory character and a certain emphasis upon qualitative analyses of data from relatively small samples of subjects.

This progress report is a summary description of part I of our project. The objectives and the investigations are treated only in an abbreviated form; more detailed reports will be presented in the future or have been presented in special reports (see Frithiof 1967, 1968; Ekstam, 1968; Nordbeck, 1968 a, b; 1969 a, b; 1970 a, b, c; Andersson, 1969; Berg, Skogman & Nordbeck, 1969; Nordbeck, Gedin & Linnér, 1969; Nordbeck & Maini, 1970).

T h e i n d i v i d u a l r e s e a r c h p r o c e s s

Research consists to a considerable extent in the production and discovery of new knowledge on the basis of previously gathered knowledge. In this production of knowledge, the individual researcher - his research activities, thoughts etc. - constitutes a decisive link irrespective of whether he works alone, in a group or as part of a larger unit. There exist studies of how the individual researcher works, thinks etc. (e.g. Rossman, 1931 (1963), Hadamard, 1945, Roe, 1953, Eiduson, 1962, Taylor & Barron, 1963, Pelz & Andrews, 1966). But what we know to date about the individual research process; i.e. research work viewed as a process linked to an individual, is to a large extent based upon biographical anecdotes or reports of personal research experiences and too little upon systematic empirical studies (c.f. Wallas, 1926; Beveridge, 1958; Ghiselin, 1963; Taylor & Barron, 1963; Coler, 1963; Mackworth, 1965; Maslow, 1966; Guilford, 1967 a, b; Boalt, 1968; TVF, 1968; Watson, 1968; Fox, 1969). The individual research process can be studied from various aspects which together provide a picture of the whole. To give a better background to the problems and

investigations within the project, we shall first give a short account of some such aspects, which are of special importance for our studies, both from a theoretical point of view and because of their relevance to our empirical data.

1. The research process viewed as a series of changes in thinking concentrated upon the identification and solving of problems. We consider the individual research process as a series of changes focused upon the ideas, knowledge, and thought-content of the researcher in a particular theme, research field or problem. (Even the emotional and motivational changes can be included here). These changes are concentrated upon two major activities - problem identification and problem-solving (c.f. Mackworth, 1965; Bunge, 1967). Problem identification comprises perception of a problem and changes in the cognition of the problem. Problem-solving includes: the perception and production of hypotheses and methods of solution, utilization of these methods, cognition of the solution, verification and changes in the details of the solution. The research process is often characterized by certain activities, more or less typical of research work, and this is especially applicable to the problem-solving part.

2. Different phases or stages in the research process.

These are, among other things characterized by the prevalence of certain research activities and one can differentiate, e.g. the following phases (c.f. Hyman, 1964):

- a. An orienting, preparatory initial phase. It is characterized by problem-perception or precursory interest in a particular research field, reviews of literature, preliminary problem formulation plus diverse ideas about methods etc.
- b. A planning phase which is often relatively more structured and goal-directed. This phase is identified through the development of instruments, planning of the investigation etc.

- c. Data-collection or analogous activities, eventually including a primary organization of data.
- d. A phase characterized by analysis and interpretation of the collected data.
- e. A final phase dominated by juxtapositioning and report writing.

The research process, and especially if one considers the research process as working with several different problems in a particular problem area, usually includes several such phases woven into each other or following each other.

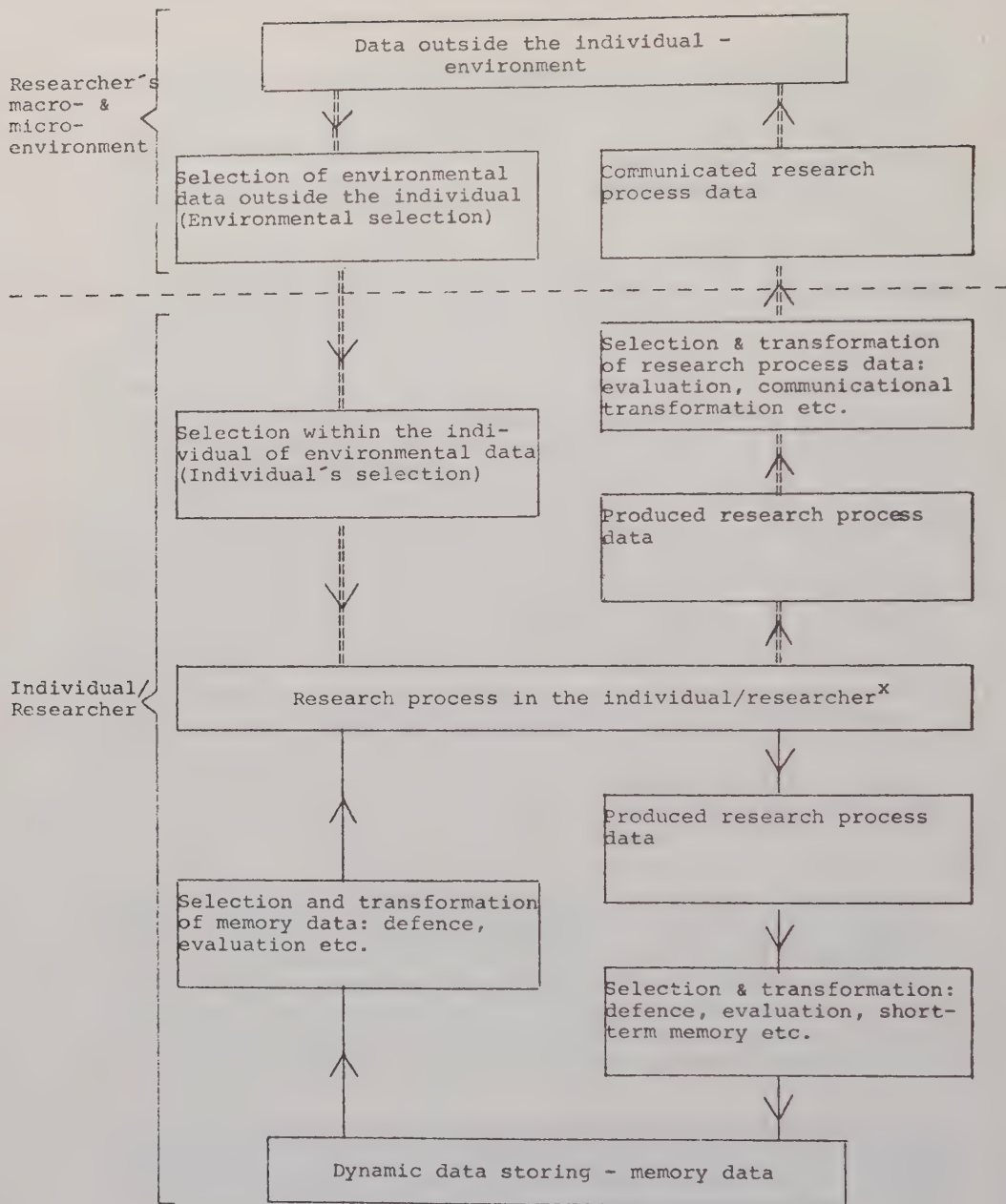
3. Factors influencing the changes in and development of the research process. It is relevant, according to our data, not only to categorize but also to study the interactions and relations between the following factors:

- a. Those pertaining to the individual, i.e. structural traits (e.g. potential creative ability, personality etc.), anamnestic factors (e.g. childhood factors, earlier research experiences etc.), and actual events and present changes (e.g. depressive moments, processing preconscious material etc.).
- b. Environmental, i.e. microfactors (e.g. reactions of research colleagues, family etc.), and macrofactors (e.g. the educational and research system etc.)
- c. Those that are directly relevant to the research situation and even those that characterize situations, experiences and events outside the research work.

4. The research process viewed as a communication system, e.g. according to the radically simplified figure on the next page, Fig. 1 (c.f. Guilford's problem-solving model, 1967 a). It would be diverging too far to go into detail about the applications of this working model, but we wish to mention that it has the potential of summarizing and describing the various aspects in the research process.

5. The research process as a creative activity. We deal partly with this under "The emergence of new research ideas" (p. 14), where we discuss some of the crucial aspects and our empirical data related to creative processes in research work.

Fig. 1.



^x By research process is meant that processing, irrespective of level of consciousness, which implicates successive changes of thought-content with relation to the research theme. The flow and selection of data, described above, to and from the research process is applicable both for a whole long-drawn process and for one phase or stage in this process.

6. The research process including individual critical moments and event-sequences (see below).

C r i t i c a l m o m e n t s a n d p r o c e s s e s
i n r e s e a r c h w o r k

Research work consists of several different activities and events. We assume that in every researcher's work there exist certain isolated or repeated sections, periods, incidents or event-sequences which are described or experienced as being more decisive or crucial for the direction, development, and results of his work than other parts of the research work. We refer to them as critical moments. That critical moments in this sense exist is supported by the investigations we have carried out, by biographical and other descriptions of research work, plus the personal experience of many researchers.

The only empirical study of critical moments in research work carried out, as far as we are aware, is "Critical Requirements for Research Personnel" by Flanagan (1949, 1963). Differences in the objectives, methods etc., make a direct comparison of it to our work rather difficult. Certain aspects of what we refer to as critical moments have been touched upon at other places in literature, mostly in biographical form (e.g. Beveridge, 1958; Kubie, 1958; Ghiselin, 1963; Maslow, 1966; Watson, 1968; Fox, 1969). But these descriptions are not structured upon systematically collected empirical material. On the whole there is a dearth of scientific analysis of this particular field.

Aims

Past research and general experience provide only certain general intimations about various types of critical moments and their relative frequency. The number of possible moments is actually quite large. We have therefore arranged our investigations in a manner such that the data gathered would provide a better background for further research.

The aims of the investigations carried out have been:

1. Attempts to gain a synopsis of the most common types of critical moments and processes. (Presented on pp. 9-11 under the heading - Results.)
2. Further, to provide a detailed description of the important aspects of some of the most frequent critical moments and processes. (Presented under the headings:
 - a) Initiation of and changes in the course of research (pp. 12-14).
 - b) The emergence of new research ideas (pp. 14-19).
3. It has also been the aim that the investigations should provide certain bases for an empirically structured model of the individual research process (cf. pp. 3-7).

Investigations, subjects and methods

The results to be presented are based upon the following investigations of researchers at universities and institutes of technology:

Investigation 1. Subjects: 45 researchers from various departments, a majority were biologists.

Methods: Half-structured detailed interviews, at least two for every subject.

Investigation 2. Subjects: 28 behavioural and social scientists, a majority had psychology as their major field of research.

Methods: A short open type of questionnaire, supplemented with an interview.

Investigation 3. Subjects: 10 subjects from the behavioural sciences.

Methods: Interviews conducted in direct connection with an actual critical incident or period (e.g. a new idea). This study is still in progress.

Discussions and conversations with certain individual researchers or groups of researchers have also been vital contributory sources of information.

Most of the researchers (about three-fourths) studied are at a relatively early stage of their research career (post-graduates, newly examined PhD's etc.). This is a natural consequence of the distribution of active researchers at the university departments. Among other things, the aim of such a selection on our part has been partly to gather information of practical importance for research education and training, and partly to have a better opportunity of studying such basic factors and processes which decide the future direction and course of research of a particular researcher.

Results

The results presented here are a summary of the trends, which to a large extent are applicable to all the studied material to date. Naturally there are differences between the gathered materials but we shall ignore them in this context.

There exists a great variation among the different researchers as to what is subjectively experienced and described as critical moments. The differences are at times so profound that they tend to overshadow the similarities in certain respects. Despite these differences, there are certain moments and aspects of research work which are more often experienced as crucial and decisive than others. In this connection the all pervading and distinctive characteristics are (The percentages, regarding the number of moments with a certain characteristic, are approximated averages from the various investigations. As the moments can belong to more than one category of characteristics, the percentages do not total a hundred.):

1. A large number of the critical moments (approx. 35 % of the moments) are characterized by an initiation of or a change in the course of research, i.e. situations or periods when one heeds, starts, changes, or discontinues a particular problem-area, research field or inquiry (cf. p. 12).
2. The critical moments have often to do with informal communications with other researchers (approx. 30 %). Frequent critical moments are, e.g. certain types of stimulating discussion situations and different types of "crisis" situations involving supervisor(s).
3. Situations and periods when new ideas, insights or extensive changes in thinking of importance for the researchers actual or future research work occur (approx. 25 %), cf. p. 14.

4. Situations and periods where time, mostly with negative effects upon research, plays an important role are often reported as critical moments. It can, e.g. be periods of acute time press because one splits one's attention on too many things both within and outside the research work, and enforced long interruption of research work (approx. 20 %).

Relatively common are also the following characteristics:

5. Certain types of critical moments and situations which have to do with the practical pre-requisites for research work, e.g. one receives a research assistantship which makes research feasible, or unforeseen problems with the apparatus, investigation techniques, or research materials.

6. Different types of "critique situations", where the researcher or others are the recipients of the criticism.

7. Such types of "crisis states" in research work, which have as their primary cause the personality of the researcher rather than external factors. Important personality factors of the researcher seem to be, e.g. degree of self-confidence, frustration- and stress-tolerance, depressive tendencies, and degree of emotional involvement in research work.

8. The critical moments tend to occur with different frequencies in the various phases of research work. If, for example, one makes a rough division of the research phases into an initial, middle, and a final phase, then there are fewer critical moments during the middle-phase and more in the initial and final phases.

As mentioned earlier (p. 8), our aim is to gather more detailed information about some of the most common types of critical moments. We have therefore concentrated the further analyses and present investigations upon: a) such critical moments and processes that have to do with the

initiation of and changes in the course of the individual's research (point 1 above - further results below), b) certain aspects of the processes that lead to new ideas and insights of importance for the individual's own research work (point 3 above and p. 14).

Initiation of and changes in the course of research

Further results and comments

1. The most frequently reported situations and periods related to this category of critical moments, are those when one:
 - a. First observes, receives ideas or comes into contact with those problems or research-areas, which one would mostly be occupied with in future.
 - b. Commences to become interested, involved in or stimulated to choose a certain problem or research field, i.e. a situation characterized by changes on the motivational plane.
 - c. Interrupts work, temporarily or otherwise, upon a certain problem which had previously received relatively much time or interest, e.g. because one finds the problem "bad", the problem has been solved by somebody else, heavy criticism from other researchers, reasons of time etc.
 - d. Experiences great difficulty in restricting the problem or in formulating a clear and concise problem.
2. Among the processes related to the initiation of and changes in the course of research, we are especially interested in "the process of identification of a research problem", i.e. the processes that lead to the perception of or changes in the cognition of a problem.

Our data show that even if one places the important parts of this process at the beginning of the research process, it is generally in action, at least as far as certain aspects of the problem are concerned, to some extent throughout the research process. Thus, one can delineate the following major stages in the process of identification, considered as an integral part of the whole research process:

- a. A pre-stage, before a certain problem is perceived as a problem. During this stage the conditions are created for the perception of the problem.
- b. Perception-phase, the situation or period when the problem is perceived as a problem for the first time.
- c. Primary, introductory processing of the problem. Mostly consisting of certain cognitive and emotional internalization of the problem. At this stage also begins an orienting solution process and information collection, mostly of a more "pre-scientific" nature.
- d. More sophisticated processing (analysis and precision) of the problem in relation to research and scientific methodology.
- e. Stage of final formulation, often coinciding with the writing of the report.

A researcher is usually occupied with more than just one problem. Therefore several such problem identification processes can naturally be in action at the same time and related, more or less, to each other. These processes are sometimes terminated because one discontinues work upon the problem for various reasons. Sometimes there is a radical reformulation or modification of the originally perceived problem and this can be viewed both as a continuation of the original problem-identification process or as the commencement of a completely new such process (see Nordbeck, 1969 a, b).

The above discription has emphasized the cognitive aspects in the identification of problems. But it is to be noted that parallel to these aspects, there are the emotional and motivational ones, and decision and choice processes in action, which are equally important.

The emergence of new research ideas

Situations or periods when new and for research work important ideas, insights, or observations are made, very often are reported as critical moments (see p. 10). The most interesting aspect in our view is not just the final product, the idea, but the process through which it emerges, i.e. the so-called creative process that precedes the product. (It would be transgressing too far, to discuss here the definition of the somewhat diffuse concept of creativity. We therefore presume, for the sake of simplicity, that most are agreed upon the rough substance of this concept).

The creative process can be viewed through several aspects and there are quite a few theories, theory fragments or opinions which attempt to explain or describe it (e.g. Wallas, 1926; Patrick, 1935; Haefele, 1962; Taylor & Barron, 1963; Kris, 1964; Koestler, 1964; Guilford, 1967; Szekely, 1967; MacKinnon, 1968; Barron, 1969). It is not disputed that some of the theories are extremely powerful and have the potential of generalization (e.g. Kris). But what is characteristic, with certain exceptions, is the meagerness of empirically based data and the rather insufficient description of certain important aspects of the creative process.

Aims

In the more detailed analysis of some of the critical moments and processes in research work we are particularly interested in studying the events and phases directly preceding the clear perception of the principal features of a new idea, (i.e. the pre-idea phase), that the researcher considers as being the most crucial for the course of his research.

Methods

The results to be reported are based on methods and investigations described on pp. 8-9. The methodological problems connected to a study of emergence of ideas seem rather overwhelming. It is often very difficult for the researcher to reconstruct in detail the period preceding the idea. But it is our considered opinion that certain leads can be gained through the methods we have availed of, i.e. a detailed description of the idea-cognition situation, interviews carried-out directly after the emergence of a new idea, relatively frequent follow-up interviews and finally certain supplementary experimental studies. (See also pp. 8 and 21 - "Studies in progress".)

Results

The results can be summarized as follows:

1. Decisive ideas seem most often to occur after that the individual is relatively conversant with the problem area pertaining to the idea.
2. These important ideas or thought changes occur more often both in connection with the final integration and analysis of data, and with problem-identification during

the earlier parts of the research process. Variations do exist, depending upon the type of research indulged in.

3. Sudden re-structuring ("aha - experiences") tends to appear more often when one is mentally concentrating upon something other - but often adjacent - than just the problem or aspect pertaining to the idea.

4. The time period immediately preceding the new crucial idea, or insight is especially characterized by one or more of the following:

a. Experiencing failure, uneasiness, etc. A strong emotional reaction seems, in these cases, to be one of the conditions for the impending cognitive restructuring.

b. Stimulating and informative discussions or conversations with other researchers.

c. A short or long period characterized, when compared to the immediately preceding time-period, by a considerable decrease in the conscious mental activity over the problem or the aspects concerning the new idea (low activity period or pause).

5. Positive effects of such low-activity periods (for the subsequent research work) seem often to be experienced when the period is a consequence of the person's previously decreased motivation to work with the theme or the problem. In those cases when one is hindered from working further due to external circumstances, then the effect is predominantly negative or mixed and rarely positive.

Comments: phases in the creative process

The classical stages in the creative process, as described by Wallas and others, have been the object of considerable discussion in psychological literature. Even if some of

the criticism is justified (see e.g. Newell, Shaw & Simon, 1962; Guilford, 1967 etc.) it is our opinion that the said stages can be employed as a basis for a process description of data collected in connection with our studies of "emergence of ideas".

The following is a preliminary summary of the phases in the creative process. It is based on our results of critical moments studies (p. 15), data from our experimental studies (p. 21), and reviews of literature (e.g. Wallas, 1926; Patrick, 1938; Green, 1954; Haefele, 1962; MacKinnon, 1968). In what follows, only those aspects have been given prominence (e.g. the pre-idea phase) which are of special relevance for our further analysis:

A new idea or a creative thought product can emerge in several different manners. It is difficult to find a general description which satisfactorily covers all cases, i.e. different individuals, problems and situations, and which concurrently provides a relatively detailed account of the whole process. Sometimes it (the new idea) is produced through a small series of successive changes, whereby a part or a puzzle-bit is consecutively coupled to another until the new idea emerges clearly. Such a process is characterized by a systematic and controlled approach, and contains remarkably little of surprise elements and discontinuity. At the other extreme, a creative process is characterized more by one sudden restructuring and thus contains the surprise element, etc. Between these two extreme types several variants are possible.

A protracted creative process can include or be built-up of several short-term creative thought processes of one or the other type. Further, according to our present working-hypothesis, the process leading up to every small partial change, on the whole contains the same phases in micro-form as a more elaborated and time-consuming process with a sudden and radical restructuring of the thought-contents (see also the percept-genetic theory, Kragh & Smith, 1970).

One can usually delineate the following phases:

1. Initial phase, which includes:

- a. A pre-stage, when the conditions are created for the onset of the process.
- b. Identification of or focusing upon a certain theme.
- c. Orientation, and sporadic processing and information gathering.

2. Intensive activity phase: It is distinguished by a more concentrated, intensive, and sustained processing of the actual theme. The thought activity is generally more goal-directed and it is or becomes more area specific and structured than the foregoing phase. Gradually the experiencing of hindrances and difficulties increases during this phase - the eventual goals of the activity seem to be more distant. The consequences become an accumulation of discomfort, which often results in a more or less strong experiencing of failure - frustration. This in turn involves, relatively speaking, a definite decrease in motivation for continued activity in the actual theme.

3. Pre-idea phase: Frustration (in e.g. micro-situations it is mostly faintly observable) and the decreased motivation often induces a low-activity phase. The conscious thought activity, as far as the theme is concerned, during this period is relatively low and recurring only periodically. In some cases it is restricted to a monotonous harping upon certain aspects or sections of the theme and at times it can take the shape of a complete pause. The mental activity during this period is mostly or relatively more occupied by things lying beyond the theme or problem. This is what often is referred to as the "incubation period". Such pauses or low activity periods occur even during the other phases (e.g. the initial phase)

but they are often not so frequent and obvious. The low activity period is interrupted by a phase, immediately prior to the idea-cognition or insight situation, when the mental thought activity in the actual theme or a closely allied theme increases. This period of increasing activity is often characterized by certain types of regression states and also different types of stimulating situations.

4. Idea-cognition situation: The initial clear perception or experiencing of the principal features of the new idea, etc. It is, however, difficult clearly to delineate this situation from the preceding and the subsequent phases.

5. Post-idea phase: Comprising several moments, e.g., evaluation of the idea plus the development and changes of details within the principal features of the idea.

We would like to emphasize that the mutual variation and duration of the different phases can vary depending upon, e.g., the individual and the type of problem.

S t u d i e s i n p r o g r e s s

Here we shall report briefly on some of the major aspects of the work in progress, which is related to what has been described on the preceding pages. A majority of the subjects in the investigations undertaken are performing research in the field of chemistry and the rest have psychology or biology as their major field of research.

1. Studies regarding "Initiation of and changes in the course of research".

Discovery, formulation and choice of the research problem is considered by many as often being both the most fundamental, difficult and creative part of research work (e.g. Green, 1954; Hyman, 1964; Mackworth, 1965; Einstein & Infield, 1965; Bunge, 1967; Getzels & Czikszentimihalyi, 1967). These phases ought to be all the more important

for persons who find themselves in the process of research training or for those embarking on a research career. The reason being that these phases are probably decisive even for their future course of research. To our knowledge there are no empirically conducted investigations which have studied this part of research work (c.f. Pounds, 1965; Stankiewicz, 1969), and this is partly the reason why we have focused our attention upon these aspects of the research process in more detail in the subsequent analysis and investigations. And partly also as a consequence of our past results (pp. 10, 12-14). The following aspects are studied:

- a. Critical moments and factors of importance for the fact that one becomes aware of, interested in and proceeds to conduct research in particularly those research areas or problem areas (in a general sense), in which one works or has worked.
- b. Situations and periods during which new (new for the investigated researcher), more limited problems or queries are perceived and discovered, i.e. the perceptual phase in the problem identification process (described above, p. 13).

2. Studies regarding "The emergence of new research ideas".

The problem is to describe in more detail than has been done in the past aspects of the pre-idea phase, especially the occurrence of pauses or low-activity periods, and to some extent the occurrence of various types of thought-content, research activities, and emotional experiences related to the phase.

Besides the methods already described (pp. 8-9), we employ different experimental methods. To what extent experimental studies of the relevant aspects exist is a matter of opinion. One can perhaps include certain studies in the area of concept formation, problem-solving, and the psychology of thinking. The investigations that have more clear connections with our work, consist of the work of Patrick (1935, 1937, 1938) and the experimental studies about the effects of the incubation period (Gall & Mendelsohn, 1967; Fulgosi & Guilford, 1968).

The different experimental methods we have used are, e.g. "thinking aloud" during the experiment, study of the pattern of produced answers preceding the relatively most "creative" answers, and serial tachistoscopic exposure of certain types of pictures (c.f. Kragh & Smith, 1970; Maini, 1970). The task of the subjects in the experiment has been, among other things to interpret incomplete visual information.

Even if the results and conclusions of laboratory experiments and their generalization to idea-production in research settings is problematic, we do believe that such undertakings are of value because they facilitate the interpretation of information gathered through interviews etc.

3. Studies regarding "Critical moments and individual differences".

One of the conclusions of our investigations about critical moments and processes in research work is that there are considerable differences between the various researchers.

It has therefore been felt that a closer study of these differences should be made, and especially if they are related to other differences between the researchers, e.g. other data about the researcher's manner of working, research aptitude or creative ability, and diverse individual background data. The choice of variables is based upon past research in this area, our own pilot-studies, and our studies of "potential researchers" (see part II, Nördbeck & Maini, 1970).

The important categories of variables can be summarized as follows:

- A. Data regarding research and creative ability, comprising ratings (of research capacity, intuition etc.), research productivity, and experimental data or test results (e.g. ability to actualize and formulate briefly problems within one's subject area).
- B. Biographical and other background data consisting of general background data (e.g. sex, parental education level etc.), degrees and grades, and interest in and future plans for a research career (c.f. studies by Smith, Albright et al., 1961; Taylor, 1964 etc. regarding biographical differences between more and less creative researchers).
- C. Other data regarding research work including degree of personally experienced involvement in problems, amount of labour (in terms of time) devoted to research, and degree and exchange of informal communication with other researchers in the form of direct contacts. Regarding the latter variable, we have found in our investigations a relationship, expected from past research (e.g. Pelz & Andrews, 1966 etc.), between the amount of informal research communication and certain measures of research capacity and productivity (Ekstam, 1968; Nördbeck, 1969 b).

C o n c l u d i n g r e m a r k s

Research work consists of a complex network of different processes and activities. To get a better view of the most important aspects for further study, we have investigated the moments and periods which are most often experienced as being crucial for the individual's research work. On the basis of these explorations, we have gradually concentrated the analysis upon a few major aspects, e.g. the emergence of new research ideas

These studies of critical moments and processes in research work have even several connections with part two of the project, i.e. studies in the selection of potential researchers. From, for example, a theoretical viewpoint the critical moments in research work often function as factors of selection for those who would become researchers. Further, these critical moments are partly a result of the existing principles of selection and characteristics of the researcher selected. The relationship between the two parts of our project is also expressed through our utilization of equivalent instruments and variables in certain instances. The choice of similar or same subjects in both parts of the project also increases the chances of comparative follow-up studies.

References

- Andersson, L. (1969). En grupp nytexaminerade civilingenjörer vid Lunds Tekniska Högskola. Relationer mellan studieresultat, kreativitets- och intelligensvariabler samt självbiografiska data. (A group of newly examined Civil Engineers at the Inst. of Technology Lund. Relations between study results, creativity, intelligence and biographical data). Lund: Dept. of Psychol. (Mimeo.)
- Barron, F. (1969). Creative Person and Creative Process. New York: Holt, Rinehart and Winston, Inc.
- Berg, L., Skogman, A.-L. & Nordbeck, B. (1969). Psykologiska studier av tre-betygsstuderande inom matematisk-naturvetenskapliga fakulteten. (Psychological studies of "majors" students at the faculty of Mathematics and Natural Sciences). Stockholm: Committee on Research Economics, Nr. 38.
- Beveridge, W.I.B. (1957). The Art of Scientific Investigation. London: Mercury Books.
- Boalt, G. (1968). Forskningsprocessen. Stockholm: Almqvist & Wiksell.
- Bunge, M. (1967). Scientific Research. Part 1. The search for system. Part 2. The search for truth. Berlin: Springer.
- Coler, M.A. (Ed.). (1963). Essays on Creativity in the Sciences. New York: University Press.
- Ekstam, K. (1968). Kommunikation och produktivitet på två forskningsinstitutioner - en allmän översikt. (Communication and Productivity at two research departments - a general view). Lund: Dept. of Psychol. (Mimeo.)

- Einstein, A. & Infeld, L. (1965). Fysikens utveckling: Idéutveckling från äldre åsikter till relativitets- och kvantteorin. Stockholm: Natur & Kultur.
- Eiduson, B.T. (1962). Scientists: Their psychological world. New York: Basic Books Inc.
- Fulgosi, A. & Guilford, J.P. (1968). Short-term incubation in divergent production, Amer. J. Psychol. 81 (2). Pp. 241-246.
- Frithiof, P. (1967). A selected, annotated bibliography of materials related to women in science. Lund: Research policy Programme. (Mimeo.)
- Frithiof, P. (1968). Women in Science: a theoretical discussion in preparation for a field study of women scientists in Sweden. Technology and Society, No 4.
- Fox, D.J. (1968). The Research Process in Education. New York: Holt, Rinehart and Winston, Inc.
- Flanagan, J.C. (1949). Critical requirements for research personnel. Pittsburg: American Institute for Research.
- Flanagan, J.C. (1963). The definition and measurement of ingenuity. In C.W. Taylor and F. Barron (Eds.). Scientific Creativity: its recognition and development. New York: J. Wiley & Sons.
- Ghiselin, B. (Ed.). (1963). The creative process. New York: Mentor Books.
- Guilford, J.P. (1967 a). The nature of human intelligence. New York: McGraw-Hill & Co.
- Guilford, J.P. (1967 b). Creativity: Yesterday, today and tomorrow. J. Creative Beh., Vol. 1, No 1, Pp. 3-14.

- Green, E.I. (1954). Creative thinking in scientific work. Electrical engineering, 78, June, 489-494.
- Getzels, J.W. & Csikszentmihaly, M. (1967). Scientific Creativity. Science Journal, Sept. Pp. 280-284.
- Gall, M. & Mendelsohn, G.A. (1967). Effects of facilitating techniques and subject-experimenter interaction on creative problem solving. J. Pers. and Soc. Psychol., Vol. 5, No 2. Pp. 211-216.
- Hadamard, J. (1949). The psychology of invention in the mathematical field. New York: Dover Publications, Inc. 1954.
- Hyman, R. (1964). The Nature of Psychological Inquiry. New York: Prentice-Hall Inc.
- Haefele, J.W. (1962). Creativity and Innovation. New York: Reinhold.
- Kubie, L. (1958). Neurotic distortion of the creative process. Toronto: Ambassador Books Ltd.
- Kris, E. (1964). Psychoanalytic explorations in art. New York: Schocken Paperback.
- Koestler, A. (1964). The Act of Creation. London: Macmillan.
- Kragh, U. & Smith, G.J.W. (Eds.). (1970). Percept-genetic analysis. Lund: Gleerups.
- Mackworth, N.H. (1965). Originality. American Psychologists, Vol. 20, No 1. Pp. 51-66.
- Maslow, A. (1966). The Psychology of Science. New York: Harper & Row.
- MacKinnon, D.W. (1968). Creativity: Psychological aspects. In The International Encyclopaedia of Social Sciences. New York: Macmillan Co. & The Free Press. Pp. 435-442.
- Maini, S.M. (1970). The correlates of Ideas. Lund: Dept. of Psychology.

- Newell, A., Shaw, G.C. & Simon, H.A. (1962). The processes of creative thinking. In Contemporary Approaches to creative thinking. Gruber, H.A. et al. (Ed.). New York: Atherton Press.
- Nordbeck, B. (1968 a). Kreativiteten som psykologiskt forskningsområde. I "Planering för kreativitet". En redovisning av synpunkter från RIFO's kreativitetsgrupp. (Creativity as a psychological field of research. In: Planning for creativity. A report of views from RIFO's creativity group). TVF, Nr 6, årg. 39.
- Nordbeck, B. (1968 b). Studies of psychological factors in research work and the process of selection of researchers from among students at universities in Sweden. Lund: Dept. of Psychol. (Mimeo summary.)
- Nordbeck, B. (1969 a). Problem, - vad är problem? (Problem, - what is problem?). Internal note: Lund: Research Policy Programme. (Mimeo.)
- Nordbeck, B. (1969 b). Forskaren och forskningens psykologi. (Sammanfattning av gjorda och planerade studier). (Psychology of the Researcher and Research - description of the project. Summary of completed and planned studies). Lund: Dept. of Psychol. (Mimeo.)
- Nordbeck, B., Gedin, S. & Linnér, G. (1969). Relationer mellan kreativitetsrelaterade variabler och planer på högre akademiska studier respektive forskarutbildning bland psykologistuderande. (Relations between variables related to creativity and plans for higher academic studies and research education among psychology students). Lund: Dept. of Psychol. (Mimeo.)

- Nordbeck, B. (1970 a). Forskaren och forskningens psykologi. Projektbeskrivning i samband med ansökan. (Psychology of the Researcher and Research. Description of the project for a research grant). Lund: Dept. of Psychol. and Research Policy Programme. (Mimeo.)
- Nordbeck, B. (1970 b). Kritiska moment i forskningsarbetet. Beskrivning av ett projekt. (Critical moments in research work. Description of a project). Lund: Dept. of Psychol. and Research Policy Programme. (Mimeo.)
- Nordbeck, B. (1970 c). Selektionen av forskare. Studier av "blivande forskare" vid universitet och högskolor. Projektbeskrivning. (Selection of researchers. Studies of "potential researchers" at universities and institutes of technology, Project description). Lund: Dept. of Psychol. and Research Policy Programme. (Mimeo.)
- Nordbeck, B. & Maini, S.M. (1970). Psychology of the Researcher and Research: Studies in the selection of potential researchers. Project Progress Report - Part II. Psychol. Res. Bull., Lund Univ., 10, No 12.
- Pelz, D. & Andrews, F.M. (1966). Scientists in organizations. New York: J. Wiley & Sons Inc.
- Pounds, W.F. (1965). The process of problem finding. Sloan School of Management, MIT. Pp. 148-165. (In Soelberg, P. (1967). A study of decision making: Job choice. Cambridge, Massachusetts: MIT Press.)
- Patrick, C. (1935). Creative thought in Poets. Archives of Psychol., No 178.

- Patrick, C. (1937). Creative thought in artists. J. Psychol., 5. Pp. 35-73
- Patrick, C. (1938). Scientific thought. J. Psychol., 5. Pp. 55-83.
- Roe, A. (1953). The making of a scientist. New York: Dodd Mead.
- Rossman, I. 1931 (1963). Industrial Creativity. The psychology of the inventor. New York: University Books Inc.
- Smith, W.J., Alknight, L.E., Glennon, J.R. & Owens, W.A. (1961). The prediction of research competence and creativity from personal history. J. App. Psychol., Vol. 45, 1. Pp. 59-62.
- Stankiewicz, R. (1968). The role of informal research in integration and coordination of research. Stockholm: Committee on Research Economics, No 37.
- Székel, L. (1967). The creative pause. The Intern. J. of Psycho-analysis, Vol. 48, Part 3.
- Taylor, C.W. & Barron, F. (Eds.). (1963). Scientific Creativity: its recognition and development. New York: J. Wiley & Sons Inc.
- Taylor, C.W. (Ed.). (1964). Creativity: Progress and Potential. New York: McGraw Hill Inc.
- TVF. (1968). Planering för kreativitet. (See Nordbeck, 1968 a),
- Wallas, G. (1926). The art of thought. New York: Harcourt Brace.
- Watson, J.D. (1968). The Double Helix. A personal account of the discovery of the structure of DNA. London: Weidenfeld & Nicolson.

A b s t r a c t.¹ - Twenty eight researchers in the behavioral sciences were requested (through a questionnaire, followed-up by an interview) to provide information about such moments as had been the most critical for the progress of their research. The moments were characterized by motivational and/or cognitive changes. A comparison with a previous investigation of natural scientists showed more similarities than differences with respect to the characteristics of the critical moments. In both investigations there was, e.g. a high frequency of critical moments related to the initiation of and changes in the course of research, to interpersonal situations, and to production of new ideas. The differences mostly referred to negative moments, e.g. the natural scientists (more often than the behavioral scientists) reported moments pertaining to time and to difficulties connected with materials and apparatuses. Also reported were different approaches for the collection and structuring of data.

Biographical and anecdotal information from various sources (e.g. Beveridge, 1957; Kubie, 1958; Ghiselin, 1963; Watson, 1968; Fox, 1969) contains a considerable number of reports of events considered crucial for the course of the scientists's research. Such crucial events are referred to as "critical moments", and are defined as such isolated or recurrent incidents and periods experienced by the researcher as being crucial for the progress and results of his research (see Nordbeck & Maini, 1970).

Critical Incident Technique, as developed by Flanagan, has seen considerable application in military and industrial

¹The present study was supported by a grant from the Tri-Centennial Fund of the Bank of Sweden and the Swedish Social Science Research Council.

settings (Andersson & Nilsson, 1966), but its use has been limited as far as research situations are concerned. The only empirical studies of critical incidents in research work, as far as we are aware, are those of Flanagan and his associates (1949, 1964, 1963). In the 1949 investigation the critical incidents were distributed into eight major areas and involved a relatively higher proportion of accounts regarding the following three areas: (a) conducting the investigation, (b) preparing reports, (c) planning and designing the investigation. These and other areas were also analysed with respect to whether they contained effective or ineffective incidents. More effective (25% more) than ineffective incidents were reported. Further, a list of critical requirements in terms of behavior was arranged in checklist form for use in evaluating job performance. Differences in objectives and methods make a direct comparison of this study with our work rather difficult, e.g. Flanagan (1954) says that for an incident to be critical, it "must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to have little doubt concerning its effects" (p. 327). We have been more keen to study that which is subjectively experienced as critical, and our approach can be characterized as being primarily phenomenological.

In some pilot investigations (Nordbeck, 1969), mostly with natural scientist as subjects, the critical moments were divided according to their positive and negative contents. The positive moments described experiences which contributed to increased research motivation or cognitive development, and the negative moments were characterized by cognitive stagnation and decreased motivation for research. Their chief characteristics can be summarized as follows:

The most frequent positive moments are situations and periods:

1. When a new course of research is initiated, i.e. problem identification and problem choice situations.
2. When the researcher experiences strong stimulation and an apparent increase in motivation for his research through, e.g. the production of a new solution related to his current research problems, informal direct contacts with other researchers (collaboration and certain types of discussions).
3. Characterized by the creating or making of a new research product (ideas, observations and results) by the researcher himself, particularly if it is unexpected and leads to the identification of a problem important for his continued research.

The negative moments were most often situations and periods characterized by:

1. The researcher's negative feelings (e.g. depressive periods) and a definite decrease in his motivation for research work. This was usually described as a 'crisis' (e.g. related to supervisory situations), or as periods of continuous difficulties (e.g. with materials, methods and apparatuses).
2. Problems related to the researcher's working style or working behavior, e.g. difficulties in the initial stages when starting something new, problems related to certain research activities as report writing or problem selection and formulation, and difficulties connected directly with the personality of the researcher.
- 2 Negative effects of the time factor on research work, e.g. its being necessary to complete certain work within a stipulated time limit, or the dividing of attention between too many things (e.g. research problems) simultaneously.

It was clear from our pilot studies that the Flanagan approach or a multiple-choice type of questionnaire would not provide sufficiently detailed and relevant information with respect to the subjectively experienced critical moments. At the same time half-structured interviews, used in our pilot studies, were found to be too time-consuming. Therefore, the present study had the following aims:

1. To try a different technique for the collection and treatment of data.
2. To gather further information about the characteristics of the subjectively experienced critical moments. Thus, a content analysis of the critical moments was performed with respect to:
 - a. The frequencies of the various categories of critical moments, and the relationships between them.
 - b. A general review of the critical moments as related to the time of their occurrence, e.g. the subject's degree of familiarity with the problem area, and the most critical research activities.
3. To compare the results to past investigations for purposes of identifying such critical moments as might be common to different disciplines.

M e t h o d

Subjects.

The questionnaire was distributed to all the researchers at a department of psychology and another department for social science research. Total number of questionnaires distributed was 37 and the number who responded was 28 (76%). Nine researchers did not reply for varied reasons, e.g. they were no longer involved in research and had left town. The distribution of the subjects according to their educational or research status at the time of the study is presented in Table 1.

Table 1. The status of the subjects at the time of the study.

Status	No. of Subjects
Beginning of Ph. D. studies	6
Middle of the Ph D studies	9
End of Ph D studies	3
Post Ph D studies	6
Established researcher	4
Total	28

Note: Post Ph D studies = The Swedish "Filosofie licentiat" is often equated to an Anglo-Saxon Ph D. The Swedish "Filosofie doktor" has no equivalent in this sense, and is normally aspired for after the "Filosofie licentiat". It consists only of research and generally takes over six years. It is here referred to as post Ph D studies. According to the 1969 university reforms, both these degrees are to be replaced by one post-graduate degree, i.e. the "Filosofie doktor".

The average age of the subjects was 32 years and it varied between 23 and 49 years. There were 23 males and five females. The number of females is low due to the small numbers at these departments and also the relatively low number who proceed with post-graduate studies (cf. Nordbeck & Maini, 1970b). The minimum research experience of the subjects was 1.5 - 2 years.

Questionnaire.

The pilot investigations (Nordbeck, 1969,) had shown that most of the subjects found it difficult, at least on the spur of the moment, to recall moments that had been the most decisive for their research and there was great variation in what was considered "critical". The present questionnaire was restricted to only such moments as had direct relevance for the course, development and results of their research;

and it was to be completed by the subjects at a time convenient to them (within a week or two from the date of distribution). The subjects were requested to describe two such moments or periods that had been the most decisive and to structure their responses around the following:

(a) When the incident or period transpired; (b) What happened; (c) Specific reason for the decisive or critical nature of the incident; (d) The effects of the moments upon subsequent research; (e) The chief cause or instigating factor. A second question asked the subjects to check for an appropriate alternative (ranging from many to none) regarding the frequency of critical moments in their research work.

Besides the direct responses to the questionnaire, we received explanatory comments from the subjects and also carried out follow-up interviews for purposes of clarification.

Category formulation

The material collected resulted in 88 moments, which is more than the expected number of 56, and is due to some subjects describing more than the stipulated two. These 88 moments often included sequences of incidents (if the sequences were divided into specific incidents, the total number of moments was 226). The raw data (consisting of the 88 moments) was transferred to cards. Each card contained a summarized description of the contents of the event and information pertaining to the points specified above.

First the descriptive categories were decided upon. Then the authors, independent of each other, classified the data into the respective categories. It is to be noted that a moment could be classified into more than one category. The

inter-judge agreement with respect to the classification was 93%. After the preliminary categorization, the various categories were scrutinized for their applicability, parsimony and coherence. Following the tentative establishment of the categories, the next step in the process was to define them, and in the light of the definitions, a reclassification of the data was performed. Later, some of the general categories were sub-divided into smaller categories, so as to facilitate the handling of the data. This process of classification, formulation and definition resulted in a total of nine major categories, and with the subdivisions the total number of categories was 22 (see Table 2). These categories were preferred to other methods of classification, e.g. distribution of the moments into internal and external factors or personality and social factors, because they reflect the central aspects of the critical moments and retain their dynamic character.

In addition to the above categorization, all the moments were also classified according to their positive and negative motivational and/or cognitive content (see below).

R e s u l t s

As Table 2 shows, the most frequent major categories are: category 1, interpersonal situations within research (56% of the total number of moments); category 2, emotional-motivational changes (55%), and category 3, initiation of and changes in the course of research (45%). (It is to be noted that category 2 includes only those moments which emphasize strong emotional-motivational changes. The classification of motivational/cognitive changes described below, includes all the moments irrespective of the emphasis and the degree of change).

Table 2. The total frequency of the critical moments (mom) and individuals (ind) in the Major and the Sub-categories.

Major category	No of mom	ind	Sub-category	No of mom	ind
1. Interpersonal situations within research: interaction of a positive or negative nature with one or more in the research milieu, either formal or informal.	49 56%	25	A. Supervisory situations	20 23%	14
			B. Other experts besides the supervisor.	9 10%	7
			C. Colleagues.	23 26%	16
			D. Direct contacts.	26 30%	19
			E. Formal group situations	12 14%	10
			F. Conflict situations.	9 10%	9
			G. Indirect contacts.	6 7%	4
2. Strong emotional-motivational changes that arouse, sustain and regulate the research behaviour of the individual.	48 55%	24	A. Frustration & failure	29 33%	19
			B. Experiences of success & achievement.	25 28%	18
			C. Self-confidence.	12 14%	7
3. Initiation of and changes in the course of research: discovery of new problem areas & changes in the direction of research.	40 45%	22	A. Problem perception & selection.	20 23%	12
			B. Stimulation for the course of research.	20 23%	13
			C. Discontinuation of research.	14 16%	11
4. Research ideas: both tangible & clear or the vague beliefs & feelings effecting research	29 33%	19	A. New ideas & insights - personal.	25 28%	15
			B. New ideas & insights - from others.	6 7%	6
5. Critical research attitude: research problem, methodological, theoretical & ideological considerations.	21 24%	16	-		
6. Time factor: enough or lack of it & as a stress factor.	15 17%	10	-		
7. Economical considerations: pertaining to both personal security & support for research.	14 15%	10	A. Employment	8 9%	5
			B. Research finance	7 8%	5
			C. Other financial factors	1 1%	1
8. Interpersonal situations outside research: with people not directly involved in the research of the subject.	6 7%	5	-		
9. Pre-university experiences: such as occurred during school days, parental influence & earlier interests.	6 7%	3	-		

Note: % calculated on the total no. of moments (88).

Among the sub-categories the most frequent are: frustration and failure, direct contacts, experiences of success and achievement, and personal ideas and insights.

Positive and Negative moments:

Every moment involved a motivational change. Increased motivation is defined as the reinforcing of interest in research work and a decrease involves a declining of interest. Certain of the moments could also be described as involving cognitive changes, i.e. cognitive development or stagnation. Cognitive development or improvement is considered relative to a preceding stage. Cognitive stagnation implies that no new ideas, insights or knowledge are gained and mistakes are discovered without any progress being registered.

The above aspects were coded in terms of the following content categories, and the distribution of the moments is shown in Table 3:

Positive content:

- M^+ : Motivational increase only, without a cognitive content.
- MC^+ : Both an increase in motivation and a noticeable cognitive development.

Negative content:

- M^- : Motivational decrease only, without a cognitive content.
- MC^- : Motivational decrease combined with cognitive stagnation.

Table 3. The distribution of the critical moments (88) in various combinations of the motivational and cognitive content categories.

Category	Positive content		Negative content	
	M^+	MC^+	M^-	MC^-
Positive content	M^+	<u>10</u>	0	2
	MC^+	0	<u>39</u>	9
Negative content	M^-	2	9	<u>10</u>
	MC^-	2	12	<u>4</u>
Total		14	60	21

Note: The figures in the diagonal (underlined) refer to the number of moments coded as M^+ , MC^+ , M^- , MC^- only, without overlapping.

Table 3 shows the striking dominance of category MC^+ , involving both a positive motivational change and cognitive development. The table also shows that 49 (56%) of the moments were positive, 25 (28%) were mixed, i.e. both positive and negative contents of equal importance, and 14 (16%) were negative.

An analysis of the effects of the moments upon the future research of the subjects showed that all but one of the positive moments, as expected, had positive effects (both immediate and long-term). A majority of the mixed moments had immediate negative effects (e.g. frustrations preceding the emergence of new ideas), but only two moments were reported as subsequently having had negative long-term effects. Only

eleven moments had negative long-term effects.

To investigate the distribution of the various categories of critical moments in terms of their positive or negative content, a further analysis of the categories was performed and the resulting distribution of the most frequent major categories is shown in Table 4.

Table 4. The distribution of the most frequent major categories with respect to the number of positive and negative moments.

Major Category	Positive moments	Negative moments	Total
1. Interpersonal situations within research.	35	14	49
2. Strong emotional-motivational changes.	24	24	48
3. Initiation of and changes in the course of research.	31	9	40
4. Research ideas.	24	5	29
5. Critical research attitude.	10	11	21

Note: The moments with an equal positive and negative content (25 mixed moments, cf. p.10) were divided equally between positive and negative within each category.

There is a clear dominance of positive moments in most of the categories but the strong emotional-motivational and critical research attitude categories are equally often experienced as positive and negative.

Among the positive moments the most frequent were:

- a. Interpersonal situations consisting mostly of direct contacts with research colleagues and somewhat less frequently with the supervisor.
- b. Initiation of and changes in the course of research, including problem perception and problem selection moments and other moments stimulating for the course of research.

The negative moments consisted of:

- a. Apparent negative emotional changes, including a strong decrease in motivation for research. In general this is due to experiences of frustration and failure in connection with research work.
- b. Certain interpersonal situations, particularly related to supervisory situations.

Relationships between the major categories of critical moments and the non-overlapping grouping of the moments

As Table 5 shows, the relationships are primarily focused around the MC^+ variable. Thus we can extract a dominant dimension characterized by a positive motivational change and a concurrent cognitive development which consists of critical moments from most of the categories, but primarily from the following: interpersonal situations within research (category 1, 36 moments), initiation of and changes in the course of research (category 3, 34 moments), emotional-motivational changes (category 2, 30 moments), and new ideas (category 4, 29 moments). The dominant dimension extracted was also verified by a simple cluster analysis (McQuitty, 1957; Nordbeck, 1965).

Table 5. Relationships between the major categories.

Categories	1	2	3	4	5	6	7	8	9	M ⁺	MC ⁺	M ⁻	MC ⁻
1	<u>49</u>	26	28	15	11	3	5	3	1	4	36	13	6
2	26	<u>48</u>	18	17	16	11	6	4	0	5	30	20	15
3	28	18	<u>40</u>	12	8	3	6	3	3	2	34	8	6
4	15	17	12	<u>29</u>	9	5	1	1	0	0	29	3	3
5	11	16	8	9	<u>21</u>	4	2	1	0	3	14	10	8
6	3	11	3	5	4	<u>15</u>	5	3	0	2	9	3	8
7	5	6	6	1	2	5	<u>14</u>	2	0	6	6	3	3
8	3	4	3	1	1	3	2	<u>6</u>	1	2	3	1	3
9	1	0	3	0	0	0	0	1	<u>6</u>	2	3	1	0
M ⁺	4	5	2	0	3	2	6	2	2	<u>14</u>	0	2	2
MC ⁺	36	30	34	29	14	9	6	3	3	0	<u>60</u>	9	12
M ⁻	13	20	8	3	10	3	3	1	1	2	9	<u>21</u>	0
MC ⁻	6	15	6	8	8	8	3	3	0	2	12	0	<u>18</u>

Note: The relationships are expressed in terms of the number of moments. Those underlined indicate the total in each category.

As Table 5 shows, there is a considerable amount of overlapping in the various categories, i.e. a moment is often characterized by more than one category. We investigated the possibility of a successive division of the moments into mutually exclusive groups with respect to a certain specific dominant characteristic. The following illustrative example clarifies this approach:

The grouping of the moments is based on a system of hierarchical categorization. It proceeds from the most frequent characteristics of the moments from among the categorizing variables used. The moments are dichotomized into two groups, one group

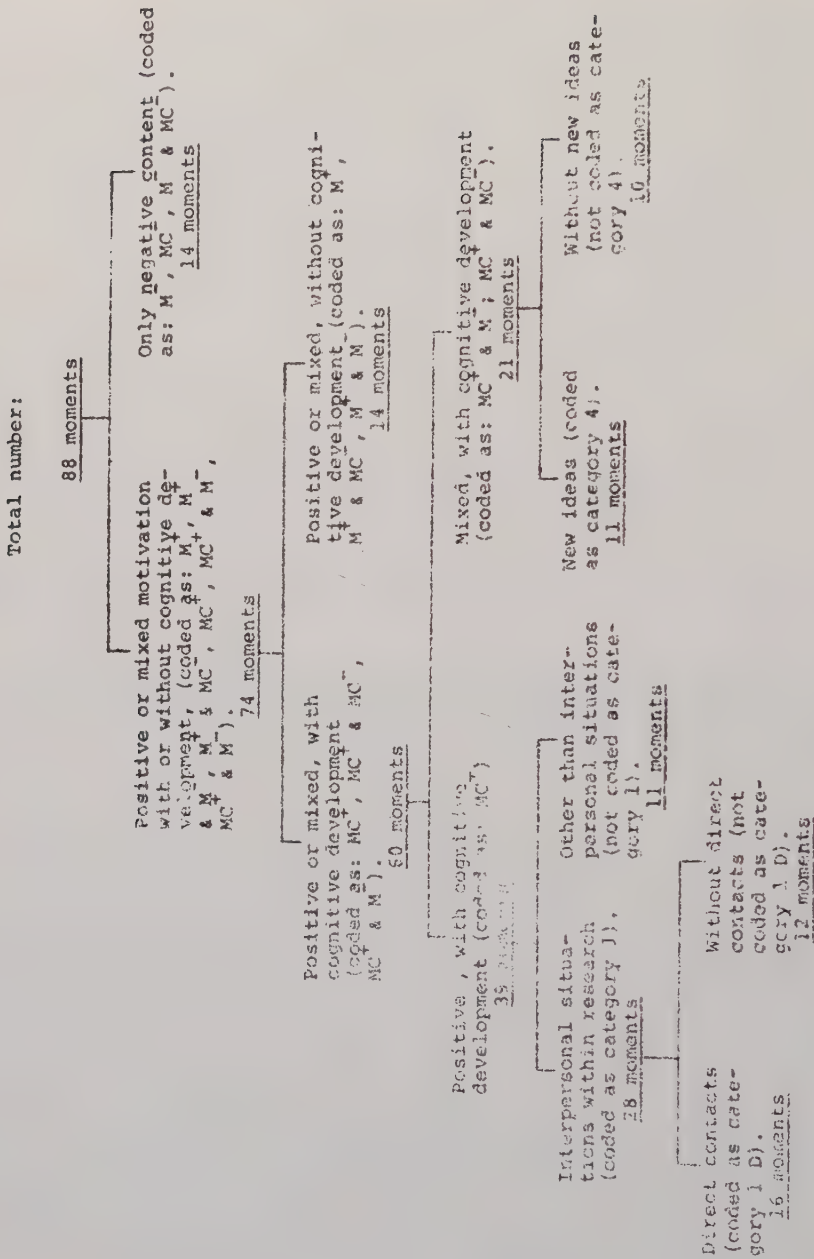


Fig. 1. Hierarchical division of the moments in "non-overlapping" groups.

displaying the frequent characteristic and the non-representation of it in the second group. The two mutually exclusive groups obtained, are then similarly divided into two further groups and so on.

Using the above technique, the total number of moments (see Fig. 1) could be divided into two groups: a positive motivational group of 74 moments with or without a cognitive development, and a second group consisting of such moments as had no positive content, i.e. 14 moments. The figure shows the subsequent steps in such an analysis. This form of analysis can be carried further until one has got a parsimonious picture of the most coherent categories. And such an analysis gave results similar to the ones obtained while processing the major and the subcategories. Due to this similarity, the results are not described in detail and the above is reported as an illustrative example of this technique of processing the data.

Sex differences

As the number of female subjects is small, no direct comparisons based on sex were performed, and the ones to be reported have to be treated with caution. There were two differences which are in line with past pilot results (cf. Nordbeck, 1969). Namely, the greater frequency on the part of the females to report moments having to do with interpersonal situations outside research (category 8), e.g. family. And similarly reports by nearly all of them about problems relating to self-confidence (category 2 C). The rest of the categories did not show as marked differences as the fore-going.

Analysis of the most frequent sub-categories

In order to get detailed information about the critical moments, some of the most frequent sub-categories were chosen for further analysis, namely: 1D, 2A, 2B, 3A, and 4A (see Table 2, p. 8).

Category 1D: Direct contacts (26 moments)

Only eight of the direct contact moments had negative contents. And the supervisor was the main cause in a majority of them. The positive direct contacts were most frequently with the colleagues in the immediate vicinity of the subject. Next most frequent were the contacts with the supervisor and third in frequency were the contacts with other authorities and experts. In general such contacts have had crucial influence upon the course and development of the subject's research, and contributed to the generation of new ideas (printed materials, e.g. books and articles, were less frequently reported as generating new ideas).

The educational career stages during which most (16 moments) of the critical direct contacts occurred were the periods at the beginning of majors and Ph D studies. With respect to the research activities, slightly more than half of the moments occurred when the researcher was involved with the perception, selection and formulation of a problem. (cf. below for a list of the research activities).

Category 2A: Frustration and disappointment (29 moments)

Interestingly enough, the long-term effects of most of these moments (65%) were experienced as positive, e.g. in seven of the moments frustrations preceded the emergence of new ideas (cf. below).

The causal factors were most often reported as being external, e.g. in seven of the moments, the supervisor was reported as being the chief source of frustrations. The critical research attitude of the subject himself or that of others toward his work was the chief cause of frustrations in twelve of the moments.

Relatively more (11 moments) of the frustrating moments are concentrated to the beginning of Ph D studies. The subjects reporting these moments are fairly conversant with the problem area - have worked in the problem area for nearly two years. (For various degrees of familiarity with the problem area, see below).

The most problematic research activities are problem perception, selection and formulation, data gathering, interpretation and integration of results, and the report writing stages.

Category 2B: Experiences of success and achievement (25 moments)

These experiences are mostly functions of:

- a. The emergence of new research ideas.
- b. Interpersonal situations within research (direct contacts with the colleagues and supervisors).
- c. Situations when the subject is praised for his research design etc, or the subject succeeds in combining the general norms of science with his own research.

The educational stage most often associated with the feelings of success is the period at the beginning of Ph D studies.

If we divide the research process into three phases (begin-

ning, middle and end), then half the moments are concentrated to the beginning phase. The following research activities have a higher frequency of experiences of success and achievement than the other activities: problem perception, selection and formulation, data gathering and processing, interpretation and integration of results and report writing. The pattern that emerges is the same as that obtained for critical frustrations and disappointments (category 2B, above).

Category 3A: Problem perception and selection (20 moments)

All the moments (with the exception of three) are positive. The main characteristic of these moments was direct contacts in the form of discussions, suggestions etc, equally frequent with both the colleagues and the supervisor. The supervisory influence is more in terms of a general influence for the choice of an area of research and the direction of research, while the colleagues have more specific influence, e.g. in the choice of a particular problem.

Most of the moments occur at the beginning of Majors and Ph D studies (40% respectively 35%).

The critical perception or choice of a problem occurs when the subject has relatively little familiarity with the problem area (in most cases the subject has read in the area only sporadically).

In the research process the moments concentrated mostly at the beginning stages.

Category 4A: New ideas and insights - personal (25 moments)

About half of all the personal idea situations are preceded by a period of negative reactions against ones own thoughts and achievements (cf. p.16). In at least half of these cases the negative reactions are not directly related to the problem or area to which the new idea pertains.

40% of the ideas are reported as having emerged when the subject least expected them ('Aha! type'), and only a few (16%) contain a description reflecting a successive development. The ideas often emerge while the subject is occupied with something adjacent to the problem area pertaining to the idea.

The long-term effects of the moments upon the course of research have been experienced as positive. But in four of the moments the short-term effects of the new ideas were reported as negative. As expected the internal factors were the most decisive, but in seven of the moments external factors were reported as being vital contributory sources. These external factors refer to direct contacts, mostly with the colleagues and less frequently with the supervisor, and the reading of literature.

The new ideas emerged most frequently at the beginning of Ph D studies. This is especially the case when compared to later Ph D stages. Nearly half of the ideas occurred during the activities characterized by interpretation and integration of own results. Even though a majority of the ideas occur during these later activities in the research process, it is to be noted that this refers to problems that are at a beginning phase, i.e. the subject is still quite remote from an acceptable solution to the problem within the framework of his research.

There is a general trend for the important ideas to occur more often when the subject is quite conversant with his problem area (worked in the area for 2 - 4 years).

A general review of the critical moments as related to the time of their occurrence

Besides the categorization of the critical moments and the results reported on the preceding pages, an analysis of all the critical moments was performed with respect to certain variables related to the time of their occurrence (without direct reference to the categories). It is to be noted that there is an over-representation of the pre-Ph Ds (cf. above), which partly explains the predominance of the moments at the initial stages of the research and educational processes.

Educational and research career stages

A study of the relationship between the current status of the subjects (beginning of Ph D, end of Ph D, etc) and the educational and research career stages (prior to university studies, during majors, post Ph D studies, etc) during which the moments occurred, showed that a majority of the moments took place during the Majors and the Ph D stages. The tendency, however, is somewhat weaker among the Post Ph Ds and established researchers. Interestingly enough the post Ph Ds more often reported moments that occurred prior to their Majors studies than the Ph D candidates (see Tables 6a and 6b). With the exception of one subject and moment, the rest of the moments are reported by four of the post Ph Ds and established researchers.

Table 6a. Relationship between current status and stage of occurrence in terms of moments.

Stage of occurrence	Current status		Total
	Pre Ph D	Post Ph D & estab. researcher	
Pre Major	1	10	11
Post Major	45	28	73
Total	46	38	84

Note: Total number of moments does not add to 88 as four of the moments were unspecified.

Table 6b. Relationship between current status and stage of occurrence in terms of individuals.

Number of individuals	Current status		Total
	Pre Ph D	Post Ph D & estab. researcher	
With Pre-Major moments	1	4	5
Without Pre-Major moments	17	6	23
Total	18	10	28

The collection of the moments to the pre-major stage is influenced by several factors, e.g. the establishment of interest for research during school days, and better stock-taking on the part of the researcher due to longer research experience.

A content analysis of the pre-major moments showed that all the moments, with the exception of two with short-term negative effects, generally had long-term positive effects upon the subject's future research. Further, these positive effects tended to decide the problem area researched into subsequently.

The post Ph Ds as a group, report more critical moments (47%) even though they represent only 36% of the total sample (see Table 7). It does seem that an experiential factor could partly explain this, i.e. this group has had more experience and had more than two incidents which were crucial and therefore they found it difficult to limit themselves to the two moments requested. The contents of the sub-categories (cf. above) were also examined with this over-representational aspect in mind and no trends specific to the post Ph D subjects were noticed.

Table 7. Distribution of the moments and subjects according to current status.

	Current status		Total
	Pre Ph D	Post Ph D	
No. of subjects	18 (64%)	10 (36%)	28
No. of moments reported	47 (53%)	41 (47%)	88

A further analysis of the moments was carried out with respect to whether the moments occurred at the beginning, middle or end of a particular stage (beginning of majors, middle of majors, end of majors etc). This resulted in a definite dominance of the moments at the beginning of an educational stage (Majors and Ph D), fewer at the end and

the least number during the middle but this again seems to be partly dependent upon the over-representation of subjects who had not finished their Ph D studies.

The research activities during which the moments occurred

A critical moment can stretch over a number of different research activities in the individual research process. And this explains the double or even triple codings in Table 8. If a particular moment was not related to any special research activity, then it was coded in the unspecified category. There is a general trend for the unspecified moments to be mostly negative.

A majority of the critical moments are concentrated at the beginning of the research process, and especially in connection with problem perception, problem selection and to a lesser extent with the problem precision activities. Further, these initial critical moments are predominantly of a positive nature. The middle periods or stages do not show many moments, but there are relatively more moments towards the end of the research process, i.e. results and report writing activities.

Of the 19 moments coded in the results' activities, 13 are reported by post Ph Ds and established researchers. To these subjects the results stage seems to be more critical than to the pre Ph Ds. It is also probable that the pre Ph Ds have not been involved in these activities so often and therefore they report them less often. These differences were not in evidence with respect to the problem perception, selection and precision activities, which were independent of the educational status of the subjects.

Table 8. The research activities during which the critical moments occurred.

Research activities	No. of moments
1. Problem perception and identification	20
2. Problem selection	26
3. Problem precision (formulation)	10
4. Literature review - orientation	6
5. Method and/or technique perception	3
6. Method and/or technique selection	6
7. Method and/or technique development	3
8. Organization and design	0
9. Hypothesis	3
10. Handling of research objects	0
11. Data gathering	7
12. Data processing	6
13. Results - detailed analysis & interpretations	10
14. Results - integration and conclusions	9
15. Literature review - verifying	1
16. Report writing	10
17. Unspecified	18

Degree of familiarity with the problem area and the occurrence of the critical moments.

Most of the critical moments occur when the subject has worked in the problem area for 1/2 - 2 years (see Table 9).

The explanation for the large number of critical moments prior to the four year period are varied, e.g. difficulties are realized after the initial pilot work, the educational status of a majority of the subjects (64% are pre Ph Ds).

Table 9. Degree of familiarity and the occurrence of the critical moments.

Degree of familiarity	No. of moments
1. Completely new or a neophyte in the area	10
2. Sporadic orientation in the area	12
3. Somewhat conversant; pilot work, in the area	22
4. Fairly conversant; worked 1/2 - 2 years in the area	23
5. Quite conversant; worked for 2 - 4 years	17
6. Very conversant; worked for 5 years and more	6
7. Unspecified, long periods or repeated situations	2

Note: Due to overlapping the total number of moments does not add to 88.

When the research activities and the degree of familiarity were examined together, it was noted that the concentration of the critical moments to the initial activities in the research process is closely related to the degree of familiarity. Another trend of interest was that with increased familiarity there was a concomitant increase in the negative nature of the critical moments, but no definite conclusions could be drawn as to this trend.

The occurrence of critical moments in research work in general.

The questionnaire contained a second question requesting the subject to check for the alternative best describing the occurrence of critical moments in their research work in general. The distribution of the responses and the alternatives are:

Alternative	No. of subjects
A. Many	5
B. Some	15
C. A few	1
D. None	4
No response	3

Thus a majority of the subjects believed that some especially decisive moments had occurred during their research work. Those who did not check any of the alternatives (No response) and those who checked alternative D, described at least two moments which had been crucial for the development, results and course of their research.

No clear trends were observed regarding the educational or research career status of the subjects and the checking of the alternatives above, even though the post Ph Ds as a group reported more moments than the pre Ph Ds.

D i s c u s s i o n a n d c o n c l u d i n g r e m a r k s

One of the aims of this investigation was to compare the results of a previous investigation of natural scientists (Nordbeck, 1969) and the present one of behavioural scientists with respect to the similarities and differences in the moments that are experienced as critical. It is to be noted that reference is only made to such moments as are experienced and reported by the subjects as critical, and not all moments (irrespective of their critical nature) that can and do occur in the course of research.

Despite the methodological differences between the two studies, there is a considerable amount of consistency in the characteristics of the critical moments, and these can be summarized as follows:

1. The similarities in the characteristics of the critical moments apply especially to the positive moments, i.e. those involving motivational increase and cognitive development. The most frequent positive moments in both the investigations consisted of:
 - a. Situations pertaining to the course of research, e.g. identification and selection of a problem. This is an interesting result because from a theoretical viewpoint, it is often considered as a very important part of research work (c.f. Nordbeck & Maini, 1970). But in investigations comparable to ours (e.g. Flanagan, 1949; Taylor, Smith & Ghiselin, 1963), these types of moments are not reported at all or only in a relatively low frequency. These discrepancies in the importance attached to these types of moments may be due to several reasons, e.g. our scientists reported their own experiences of research work in a more "free" interview or questionnaire. Further the majority of the scientists in the other investigations were probably from organizations or institutions where the problem is usually obtained from a superior or the supervisor, thus limiting the freedom of choice of the researcher.
 - b. Interpersonal situations of an informal nature which are more often experienced as crucial by the researcher than formal situations (lectures, literature etc). The importance attached to informal communications is in accordance with the results reported in other studies (c.f. Pelz & Andrews, 1966, Ekstam, 1968; Stankiewicz, 1968; Crane, 1970; Garvey & Griffith, 1971).

- c. Situations involving strong emotional-motivational changes regarding research work in general or a specific problem or research activity.
 - d. Situations involving the emergence of new research ideas or the realization of important research achievements by the researcher himself.
2. The main similarities in the two investigations with respect to the negative moments were the following:
There was a high frequency of:
- a. Situations characterized by a strong decrease in motivation for research. These were the most frequent types of negative situations in both the investigations.
 - b. Interpersonal situations pertaining to research supervision.
 - c. Moments related to the initiation of and changes in the course of research. The behavioural scientists (psychologists) more often reported moments having to do with the discontinuation of research in a particular problem area, while the natural scientists (biologists) more frequently reported moments having to do with the choice of a problem or difficulties encountered in restricting the problem under investigation.

Besides the results summarized above, there were the following similarities:

1. Positive moments involving a motivational increase and cognitive development are reported more often by both the groups than negative moments. But the relative number of negative moments reported by the natural scientists was greater than that reported by the behavioural scientists. This seems to be largely a function of half-structured interviews used with the natural scientists and the specific probing for 'crisis' type of moments or situations.
2. A majority of the moments occurred during the initial stages in the educational (i.e. beginning of majors and Ph D studies), and the research process (i.e. problem perception, identification and selection). For example, most of the new ideas emerged at the beginning of Ph D studies. A majority of the moments that occurred in the initial stages tended to have positive effects on the future course of the scientists' research. Activities at the end of the research process, i.e. results and report writing activities, were also reported as being critical, but less frequently than the initial stages. The clustering of the moments to the initial stages is partly due to the limited experience of the Ph D candidates.
3. The most frequently reported precursors of the critical new ideas were negative experiences and direct contacts. Several subjects reported that such experiences were not related directly to the problem area consanguineous with the idea that emerged. There was a clear dominance of ideas that had emerged suddenly (Aha! type). Similar trends were also observed in the previous investigation of natural scientists (see also the model of the phases in the creative process, Nordbeck & Maini, 1970).

Bearing in mind these results, published biographies, etc., one can tentatively formulate the following hypothesis: there are certain similarities, in accordance with the results summarized above, in the moments experienced as critical by the researchers at most or all research departments independent of discipline. This would especially be applicable to the research work of the Ph D candidates.

Despite the similarities, there were some apparent differences between the two investigations, mainly with respect to the characteristics of the negative moments:

1. "Critique" situations, as important negative experiences were reported by both the groups, but very seldom by the natural scientists. This could be due to personality differences between the two groups, (e.g. the psychologists as a group are more sensitive to aggression), or due to the research climate at the respective departments (cf. Ekstam, 1968).
2. The relative frequency of "time" as a crucial negative factor varied between the two groups. The natural scientists reported it much more often than the behavioural scientists. This difference can be due to various factors, e.g. differences in the techniques of data collection employed in the two investigations, a more clear defining of the "research frontiers" in the natural sciences and thus the creation of keen competition to be first.
3. Critical moments regarding the construction, maintenance and procuring of materials, apparatuses and research objects were reported more often by the natural scientists than by the psychologists.

4. Certain differences due to the lack of equivalent forms of collection and processing of data, e.g. "research style" and personality variables were obtained in the previous investigation, while equivalent information was not available in the present study.

Some of the differences noted above lead naturally to the question of techniques of data collection. Certain techniques, e.g. forced-choice type of questionnaire, are automatically excluded due to their restrictive nature and lack of applicability to exploratory/descriptive studies (see also p. 3). The combined technique, (open-type of questionnaire and a follow-up interview), used in the present study facilitates the structuring and understanding of a complex area and the elucidation of certain problems that need further research, e.g. in the present study information about the pre-idea phase and certain crucial aspects related to it (frustration and a form of displacement of the problem). Another important dimension that emerged was the role of informal direct contacts and their practical implications. The combined technique does provide information comparable to that collected through a time-consuming half-structured interview (used in our previous studies). The major difference between the two techniques lies in the quantity and depth of information gathered.

The structuring and analysis of data is always intimately related to the aims of the study. In the present study different methods of processing the data were utilized and the ones reported, corroborated each other. It is possible to improve these methods or combine them with other statistical techniques, e.g. cluster analysis (cf. p.12), and Q-analysis.

The "reconstruction" of events that transpired during the past, is the main problem associated with questionnaires and interviews. This (reconstruction) is in turn influenced by various factors, e.g. the subjects present psychological status, conscious or unconscious distortion, social desirability, general memory ability, and lack of insight into the meaning of ones own past activities. Judging from the rate of concordance in the results of the two investigations where the data were gathered through alternative techniques, it does seem that the role of most of these factors was limited.

This investigation has produced several interesting results. But only the ones specifically related to the objectives of the present study were discussed. It is aimed that the results would generally provide a certain amount of empirical data for developing a model of the individual research process, with special reference to critical moments.

References

- Andersson, B-E. & Nilsson, S-G. (1966). Arbets- och utbildningsanalyser med hjälp av critical incident metoden. Göteborg: Akademiförlaget.
- Beveridge, W.I.B. (1957). The art of scientific investigation. London: Mercury Books.
- Crane, D. (1970). The nature of scientific communication and influence. Intern. Social Science Journal, vol. 22, No. 1., 28-41
- Ekstam, K. (1968). Kommunikation och produktivitet på två forskningsinstitutioner - en allmän översikt. (Communication and productivity at two research departments - a general view). Lund: Dept. of Psychol. (Mimeo).
- Flanagan, J.C. (1949). Critical requirements for research personnel. Pittsburg: American Institute for Research.
- Flanagan, J.C. (1954). The critical incident technique. Psychol. Bull., 51, 327-358.
- Flanagan, J.C. (1963). The definition and measurement of ingenuity. In C.W. Taylor and F. Barron (Eds.). Scientific creativity: its recognition and development. New York: J. Wiley and Sons., 89-98.
- Fox, D.J. (1968). The research process in education. New York: Holt, Rinehart and Winston, Inc.

- Garvey, D. & Griffith, C. (1971). Scientific communication. Its role in the conduct of research and creation of knowledge. Amer. Psychol., vol. 26, No. 4, 349-362.
- Ghiselin, B. (Ed.). (1963). The creative process. New York: Mentor Books.
- Kubie, L. (1958). Neurotic distortion of the creative process. Toronto: Ambassador Books Ltd.
- Maslow, A. (1966). The psychology of science. New York: Harper and Row.
- McQuitty, L.L. (1957). Elementary linkage analysis for isolating orthogonal and oblique types and typal relevancies. Educ. Psych. Meas., 207-229.
- Nordbeck, B. (1965). Kognitiva åldersdifferenser. (Cognitive age differences). Lund: Dept. of Psychol. (Mimeo).
- Nordbeck, B. (1969). Forskaren och forskningens psykologi. (Projektbeskrivning. Sammanfattning av gjorda och planerade studier). (Psychology of the researcher and research - description of a project. Summary of completed and planned studies). Lund: Dept. of Psychol. (Mimeo).
- Nordbeck, B. & Maini, S.M. (1970a). Psychology of the researcher and research: Critical moments and processes in research work. Project Progress report - Part I. Psychol. Res. Bull., Lund Univ., 10, No. 11.
- Nordbeck, B. & Maini, S.M. (1970b) Psychology of the researcher and research. Studies in the selection of potential researchers. Project Progress report - Part II. Psychol. Res. Bull., Lund Univ., 10, No. 12.

- Pelz, D. & Andrews, F.M. (1966). Scientists in organisations. New York: J. Wiley & Sons Inc.
- Stankiewicz, R. (1969). The role of informal communication in integration and coordination of research. Stockholm: Committee on Research Economics. No. 37.
- Taylor, C.W., Smith, W.R. & Ghiselin, B. (1963). The creative and other contributions of one sample of research scientists. In G.W. Taylor & F. Barron (Eds.), Scientific creativity. Its recognition and development. New York: J. Wiley & Sons Inc.
- Watson, J.D. (1968). The double helix. A personal account of the discovery of DNA. London: Weidenfeld and Nicolson.

Critical moments, the creative process and research motivation

A discussion of results based on empirical studies of scientists

S. M. Maini and B. Nordbeck

S. M. Maini and B. Nordbeck are both research fellows in the Department of Psychology of the University of Lund (Sweden). During recent years they have been working on the psychology of science, on which they have published several articles. Their research has been supported from the Tricentennial Fund of the Bank of Sweden.

The future development of mankind to a large extent rests on the inventions, innovations and the creative ideas of human beings. Most would acknowledge the importance of research for both the society and the individual researcher. Our knowledge of how these vital contributions are produced is mostly restricted to readings from and analysis of biographical writings of the pioneers of science. The work of the scientists at the frontiers of knowledge is being studied by, for example, the philosophers of science, historians of science and the relatively new group interested in science and public policy (Holten, 1970). A general consensus exists among these specialists that there is a dearth of knowledge about the 'intellectual biography' of scientific ideas.

The relatively new field of 'psychology of science and the scientist' has shown marked success in its attempts to study this diffuse area (cf. Albert, 1969; Singer, 1971). Various approaches have been employed and among these are laboratory methods (e.g. Patrick, 1935), psychometric and psychiatric techniques (e.g. Roe, 1953; Barron, 1968), biographical, pathobiographical and autobiographical materials (e.g. Ghiselin, 1963; Taylor, 1964; Giovacchini, 1966; Székely, 1967).

All the approaches have their merits and demerits but it does seem that this new area has to be approached from all angles and through such methods as are conducive to systematic, scientific observations, which would lead to the structuring of a theory to cover this field. We have used various techniques and methods in our attempts to gain insight into the 'psychology of the researcher and the research process' (Nordbeck and Maini, 1970a). The studies have mostly concentrated around the thoughts, ideas, research activities, and so on of the individual researcher who provides the decisive link in the production of knowledge. This researcher may work alone, in a group or as part of a larger unit, but everywhere he provides the vital link in the development of science. His research procedure gives us access to such aspects as the creative process, motivation for research, etc.

The present article is a summary and discussion based on the empirical findings from three of our investigations. These studies were devoted to, among other things, critical moments in research work, the creative process, and motivation for research. In the first investigation (Nordbeck, 1969, 1972), semi-structured interviews were employed to gather information about critical moments in the research work of natural scientists (mostly biologists). The second study (Maini and Nordbeck, 1972) utilized a questionnaire followed up by an interview of social scientists (mostly psychologists). The third investigation (Maini, 1971) made use of autobiographical data from an interdisciplinary and international group of scientists who had provided the relevant information in a 'Festschrift' in honour of Herman Wold (Dalenius *et al.*, 1970). In the investigations mentioned above, the techniques were varied and subjects (established researchers, Ph.D.s and Ph.D. candidates) chosen from various scientific disciplines. This was done in order to isolate both the universal and specific aspects of the individual research procedure.

Critical moments in research work

Biographical and anecdotal information from various sources (e.g. Beveridge, 1957; Kubie, 1958; Ghiselin, 1963; Watson, 1968; Fox, 1969) contains a considerable number of reports of events considered crucial for the course of research. Such events are referred to as 'critical moments'. They are those isolated or recurrent incidents and periods experienced by the researcher as being crucial for the progress and results of his research (see Nordbeck and Maini, 1970a). It is to be noted that the emphasis is on moments that are subjectively experienced and reported as critical by the scientist and not all moments (irrespective of their critical nature) that can and do occur in the course of research. Examples of critical moments are 'Aha!' experiences, periods of depressive feelings and inactivity, etc.

According to the results of our investigations, it seems that all moments experienced as critical and of special importance for research involved motivational changes, either positive or negative. Positive motivation refers to the reinforcing of interest in research work and negative involves a decline of interest. Certain moments could also be described as involving cognitive changes, i.e. cognitive development or stagnation, relative to a preceding stage, for instance the production of knowledge and new ideas. Cognitive stagnation implies that no new ideas, insights or knowledge are gained and mistakes are discovered without any progress being registered.

Critical positive moments

The most frequently reported moments involved positive motivation and, in most cases, a cognitive development. The most common types of these moments, also coded as positive moments, can be summarized as follows:

1. Critical situations pertaining to the direction of research, e.g. the identification and selection of a problem. This is an interesting result because from a theoretical viewpoint it is often considered as a very important part of research work (cf. Nordbeck and Maini, 1970a; Nordbeck, 1971). But in formal academic circles the processes leading to the identification and selection of a problem are often regarded as a pre-scientific stage and not to be included in the 'real' research process. In investigations comparable to ours (e.g. Flanagan, 1949; Taylor *et al.*, 1963), these types of moments are not reported at all or only with relatively low frequency. These discrepancies in the importance attached to such types of moments may be due to several causes; for example, our scientists reported their own experiences of research work in a more 'free' interview or questionnaire; they conducted research in university settings which allow more freedom than others, such as industrial research centres. Further, the majority of the scientists in the other investigations were probably active in organizations or institutions where the problem research is usually defined by a superior, thus limiting the freedom of choice of the researcher.
2. Interpersonal situations of an informal nature are more often experienced as crucial by the researcher than formal situations (lectures, literature, etc.). The importance attached to informal communications is in accordance with the results reported in other studies (cf. Pelz and Andrews, 1966; Ekstam, 1968; Stankiewicz, 1968; Crane, 1970; Garvey and Griffith, 1971).

Olby (1970, p. 976) reports on the working habits of Nobel Prize winner Francis Crick as follows:

As with Watson, so with Brenner, Crick discussed ideas and plans for experiments day after day. They never collaborated in the sense of doing experiments together at the same time . . . their particular research interests have been complementary. . . . One hour's discussion of their problems per day is the rule. On such occasions they say 'anything without having to justify it up to the hilt'. . . . They interrupt each other, to continue either in 'dialogue' or 'duologue', the ideas tumbling helter-skelter from Crick to be met by a relentless questioning from Brenner.

3. Situations involving strong emotional-motivational changes regarding research work in general or a specific problem or research activity. These changes often occur in connexion with interpersonal behaviour, emergence of ideas, etc. An example is the increased task-involvement experienced by the researcher when he progresses in his attempts at solving a problem connected with the integration and interpretation of collected data.
4. Situations involving the emergence of new research ideas or the realization of important research achievements by the researcher himself (see below, page 194).

Critical negative moments

Negative moments, involving a decrease in motivation and cognitive stagnation, were characterized by:

1. Situations implying a strong decrease in motivation for research. These were the most frequent characteristics of the negative moments in all the investigations, such as when certain methods failed and the scientist had to start afresh with a new method, or difficulties experienced while writing up the results in a formal manner for publication.
2. Interpersonal situations pertaining to research supervision. Among the younger researchers, there were general complaints about the lack of competent supervision.
3. Moments related to the limitation of, and changes in, the direction of research. The behavioural scientists (psychologists) more often reported moments connected with the discontinuation of research in a particular problem area, while the natural scientists (biologists) more frequently reported moments connected with the choice of a problem or difficulties encountered in restricting the problem under investigation.

Differences in critical moments

Despite the similarities summarized above there were some differences between the three investigations. These are partly related to the specificity of the scientists' field of research and partly due to the selective recruiting and self-selection to the different scientific disciplines (cf. Nordbeck and Maini, 1970b).

'Critique' situations as important negative experiences are seldom reported by the natural scientists. This could be due to personality differences between the scientists (e.g. the psychologists as a group are more sensitive to aggression), or to the research climate at the respective departments (cf. Ekstam, 1968).

Even though 'critique' situations were not reported so frequently by the natural scientists, 'time' as a crucial negative factor was reported more often by them than the behavioural scientists. This difference can be due to various factors, e.g. differences in the objects of study, a clearer definition of 'research frontiers' in the natural sciences and thus the creation of keen competition to be a winner in the Olympics of science.

Another group of moments reported more frequently by the natural scientists applied to the construction, maintenance and procuring of materials, apparatus and research objects. This is understandable in the light of funds needed to perform research in the natural sciences and the high costs involved in procuring and maintaining the necessary apparatus and materials, especially for biologists whose research objects need exceptional care.

All the subjects in our investigations can be divided into two age groups: an older group with research experience exceeding six years and a younger one, both in age and experience. The differences between these two groups (irrespective of field of research) are most revealing. The former (established researchers) more frequently reported moments that could be traced to their ontogenesis. These subjects, due to their longer experience, were in a position to delve quite deeply into their past and identify critical events going back, for instance, to their primary-school days, which more or less decided their future field of research. The importance of the formative years has been emphasized in amongst others, psychoanalytic circles, and in other empirical studies (e.g. Getzels and Jackson, 1962). As our data is not detailed enough, it must suffice to note this trend and hope it can be further investigated.

Another characteristic of the critical moments reported by the established researchers was that they desired periods of peace and solitude. They also referred to the reading of literature and dissertations as the source of ideas and stimulation. These two categories of critical moments were not reported so frequently by the younger researchers, and have to be considered in the light of the heavy administrative and bureaucratic burdens and the obligations of established researchers. The younger and less established researchers reported periods of negative experiences, due for instance to dividing attention between teaching duties and research, working with too many different research problems at the same time and difficulties related to keeping to planned but unrealistic work schedules.

Here it would be appropriate to echo the feelings of most of our established researchers about the increasing amount of time taken up by, in their view, non-creative and non-productive paper work and similar duties. One of our subjects described his daily routine as follows:

During term-time I enter my laboratory at 6 a.m. and close the door behind me. I work in perfect peace on my research until 9 a.m. Then the whole department is awake with life and there is no peace. I start my administrative work, and the rest of the day is spent in board meetings, etc. The only hours of concentrated research are in the early morning.

Most of the researchers (both established and young) have developed some similarly idiosyncratic routines whereby they can be 'alone' with their research problems.

The emergence of new ideas and the creative process

As already mentioned, situations or periods when new and important ideas, insights or observations occur are, very frequently, reported as critical moments. These critical ideas are only the final products of the often protracted processes

that preceded their emergence. It may be obvious, but research is not merely the 'hatching' of ideas or 'Aha!' (a naïve picture of creative thought which distorts complexity by focusing upon suddenness), but in actual fact most often the successful termination of a laborious and frustrating period. The simplicity of the solution generally conceals the difficulties and complexities behind the finished product.

The results of our investigations about the emergence of critical ideas and the processes preceding them can be summarized as follows:

1. Decisive ideas seem most often to occur after relative familiarity with the problem area pertaining to the idea. One interesting trend, which does not allow for any general conclusions, was that both neophytes in a research area and those with experience exceeding six years reported fewer ideas than the rest of the subjects. It does seem therefore that there is some kind of satiation point of knowledge within a specific area or aspect. Beyond this point, familiarity may act as a restraining rather than as a stimulating agent for the generation of radically new ideas.
2. Important ideas or thought changes occur more often in connexion with the final integration and analysis of data, and with problem identification during the earlier parts of the research process, when the researcher is still quite remote from the solution to his problem.
3. Sudden restructuring ('Aha!' experiences) tends to appear more often when concentrating upon something other than—but often adjacent to—the precise problem or aspect pertaining to the idea (a form of displacement of the idea). This is rather common an experience of which there are several examples in autobiographies (e.g. Ghiselin, 1963).
4. The period immediately preceding the new crucial idea is especially characterized by one or more of the following: (a) experience of failure, or uneasiness; a strong emotional reaction seems, in these cases, to be one of the conditions for the impending cognitive restructuring; (b) stimulating and informative discussions or conversations with colleagues; (c) a short or long period, compared to the immediately preceding, are characterized by a considerable decrease in the conscious mental activity concerning the problem or the aspects of the new idea (low activity period or pause). This so-called 'incubation period' is often reported in autobiographies, for instance by Poincaré.
5. The positive effects of such low-activity periods (for subsequent research work) seem often to be experienced when the period follows decreased motivation to work with the theme or problem. In cases of frustration due to external constraints the effect is predominantly negative or mixed and rarely positive.

Phases in the creative process

The above summary indicates that a new idea or creative thought can emerge in several different manners. It is difficult to find a general description which satisfactorily covers all cases, that is to say different individuals, problems and situations, and at the same time provides a relatively detailed account of the entire process.

The following summary of the phases in the creative process is primarily based on the conscious or manifest operations reported by our subjects, data from experimental studies (Nordbeck and Maini, 1970a) and reviews of literature (e.g. Wallas, 1926; Patrick, 1938; Green, 1954; Haefele, 1962; MacKinnon, 1968). Our data has also provided certain intimations about the role of dreams and dream-like states (e.g. waking from an anaesthesia) in the creative process. But these aspects, like attrition rate of ideas, must be studied with other techniques, as in the laboratory (cf. Maini, 1970), or through psychoanalytic therapy (e.g. Giovacchini, 1966; Székely, 1967). That psychic (preconscious) operations are vital ingredients in the creative process is supported by nearly every scientist who is introspective about his work, although the importance of conscious elaboration is also stressed. Kris (1964) has elaborated upon the role of the pre-conscious in creativity, and with respect to scientific work he says (p. 296):

The work of the mind in research and discovery does not consist only in a continuous application to the quest for a solution. A part of the work is done in preconscious elaboration, the result of which comes into consciousness in sudden advances. It is almost always possible to find traces of an inter-relation between some external stimuli and this preconscious process.

Sometimes a new idea or creative thought is produced through a small series of successive changes, whereby a part or puzzle-bit is coupled to another until the new idea emerges clearly. Such a process is characterized by a systematic and controlled approach, and contains remarkably few surprise elements and discontinuity. At the other extreme, a creative process may be characterized more by one sudden restructuring and thus contain the surprise element. Between these two extremes several variants are possible. A protracted creative process can include or be built up of several short-term creative thought processes of one or the other type. Further, according to our present working hypothesis, the process leading up to every small partial change, on the whole, contains the same phases in miniature as a more elaborated and time-consuming process leading up to a sudden and radical restructuring of the thought content (cf. the Percept-genetic theory, Kragh and Smith, 1970).

The classical stages in the creative process, as described by Wallas (1926) and others, have been the object of considerable discussion in psychological literature. Even though some criticism is justified (e.g. Newell *et al.*, 1962; Guil-

ford, 1967), in our opinion Wallas's and the following stages can be employed as a process description of data collected in connexion with our studies of the emergence of ideas and as a model (see Fig. 1) for further empirical testing. In the creative process, which involves a radical cognitive change, one can usually delineate the following phases:

1. *Initial phase*, which includes: (a) prior stage, when the conditions for the onset of the process are created; (b) identification of or focusing upon a certain theme; (c) orientation, sporadic processing and information gathering.
2. *Intensive activity phase*. Distinguished by a more concentrated intensive and sustained processing of the actual theme. This phase is considered by most as the real scientific problem-solving stage. The thought activity is generally more goal-directed and is or becomes more area-specific and structured than the foregoing phase. Gradually, experiencing of frustrations and difficulties increases during this phase—the ultimate goals of the activity seem to recede. As a result, there is an accumulation of discomfort, which often results in more or less strong feelings of failure or frustration. This in turn involves a relatively marked decrease in motivation for continued activity in the field.
3. *Pre-idea phase*. Frustration (in micro situations mostly faintly observable) and decreased motivation often induce a low activity phase. Conscious thought about the theme is relatively reduced and recurs only spasmodically. In some cases it is restricted to monotonous harping upon certain aspects or parts of the theme and at others can take the shape of a complete pause. Mental activity during this period is mostly or relatively more often occupied with matters lying beyond the theme or problem. This is often referred to as the 'incubation' period. Such pauses or low activity periods occur even during the other phases but are then not so frequent and obvious. The low-activity period is interrupted by a phase, immediately prior to the idea-cognition or insight situation, when mental activity about the central theme or a closely allied area increases. This period of increasing activity is often characterized by certain regression states and also different stimulating situations.
4. *Idea-cognition phase*. The initial clear perception or experiencing of the principal features of the new idea. It is, however, sometimes difficult to differentiate this situation markedly from the preceding and subsequent phases.
5. *Post-idea phase*. Comprising several moments, such as the evaluation of the idea in addition to the development and changes of detail within the principal features of the ideas.

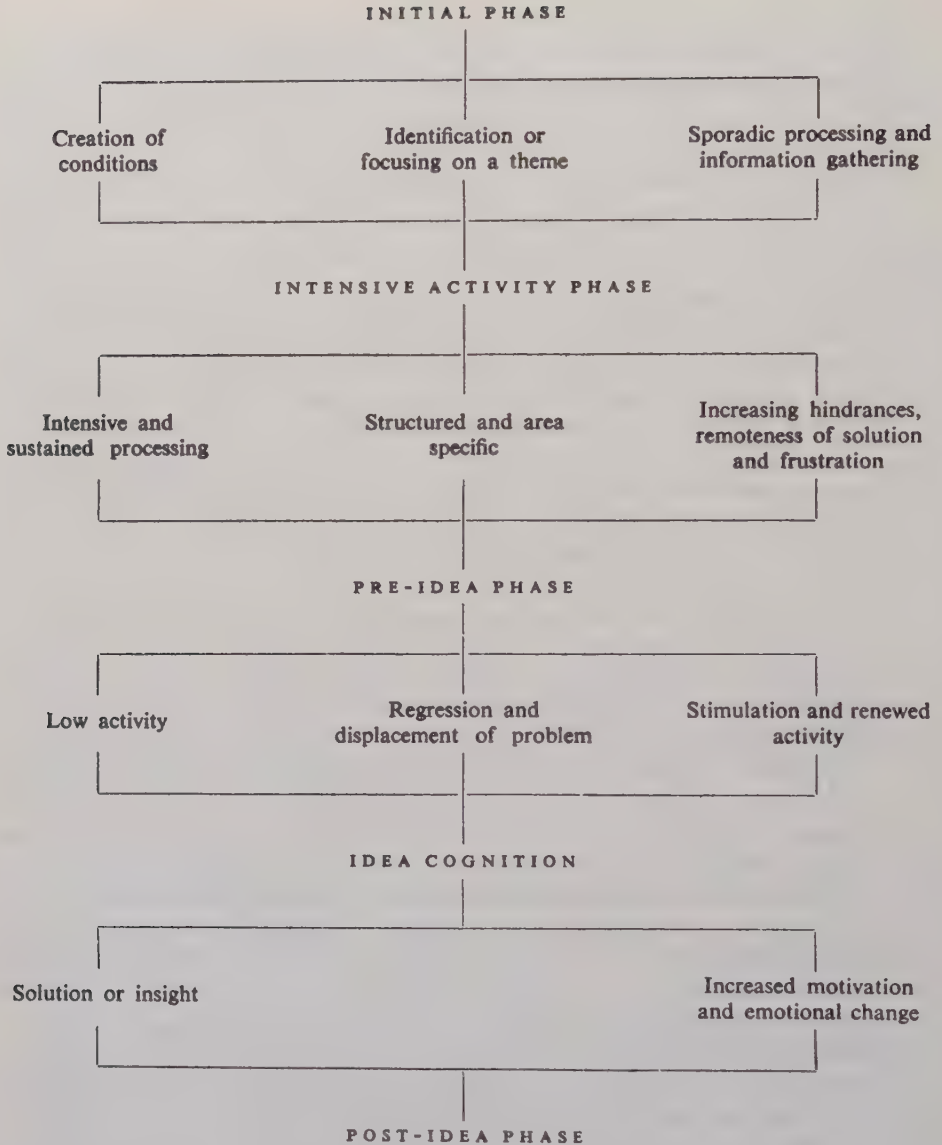


FIG. 1. Schematic representation of the creative process prior to idea cognition. (Note that there is linked variation in the duration of the different phases depending upon the individual and the type of problem. Further, one or more of the phases can merge and dominate at various stages in the research process.)

Research motivation

It is correct to assume that there are certain fundamental needs (cf. Maslow, 1954; Rapaport, 1965), which motivate men and animals alike. These have been identified as hunger, sex (libido), and so on. Other motives of varying degrees of strength are, for example, the need for security and pecuniary considerations for the satisfaction of certain basic wants. But what is it that distinguishes the researcher, particularly the creative one, from other productive contributors to society? Is it the creators' constant and often obsessive search for, and discovery of, new problems and solutions? Problems which most people are not sensitive enough to notice and which, at least initially, often give rise to frustrations and disappointments? This uniqueness of the creative person and the fruits of his labours to society, not necessarily immediate, make it both challenging and interesting for the psychologist to study his motivation, personality and the creative process.

What follows is a summary of some of our findings in the area of motivation. In psychoanalytic terms, we have so far touched upon the secondary or manifest (conscious) levels of the hierarchy of motivations. More deeper and idiosyncratic motivational factors, e.g. those pertaining to repressed motivations and their vicissitudes, must be studied with other possible clinical techniques (see e.g. Kris, 1964; Rapaport, 1965; for further details about the 'deeper' motivational explanations).

In order to obtain a clear view of the motives influencing the researcher, we have analysed descriptions of critical moments and the answers to certain questions regarding motivation (such as: Which have been the most stimulating moments in your research work?). In the autobiographical study scientists were specially requested to elaborate on their motivation for research. In the following summary of the major general factors most frequently reported as influencing the motivation of the researcher, there are certain prime motivational factors which are common to most scientists.

One of the factors most frequently referred to, in one form or another, can be subsumed under the title of 'Intellectual stimulation'. This rather broad area covers such aspects as personal involvement, curiosity, fascination, level of task involvement, love of inventing, etc. (cf. Crutchfield, 1962; Rossman, 1963; Koestler, 1964; Ekvall, 1971). Intellectual stimulation should be interpreted in rather a broad context. It includes not only the desire for solving but also the constant 'naïve' asking of questions which constantly uncover the problems that need solving. The creative researcher is normally not satisfied with just one big 'nuclear discovery', and its subsequent elaboration, as for example Copernicus and Darwin (Koestler, 1964). The creative scientist is constantly on the look-out and sees problems, feels a personal disequilibrium, where others just go blind.

What has been called intellectual stimulation is perhaps not sufficient because the researcher must experience a commitment, bordering on the obsessive, which was referred to by some of our subjects as *passionate* (cf. Taylor and Holland, 1964). Through such total immersion and the literal joy of solving problems, the researcher can afford to be shy of social relations, perhaps one of the reasons why scientists, in particular natural scientists, have been characterized as *introverted* (cf. Cattell, 1963; MacKinnon, 1967). But *introversion* can be further explained if one bears in mind that the creative scientist is sensitive not only to phenomena in the environment but also to events within himself—a form of *internal sensitivity*.

The second most frequent factor in our studies can be called the 'desire for an original contribution' which is probably embedded in the intrinsic need for novelty and change (cf. Maddi, 1965) and also interacts with intellectual stimulation. But this need or desire cannot be viewed exclusively from the individual researcher's point of view. It ought to be looked at from a wider social psychological perspective. The researcher is not oblivious to the needs of science and society. At times both merge into one. The scientist thinks only of making original and important contributions to science and thus increasing accumulated scientific knowledge in the area of deepest interest to him. Implicit in such a formulation is the societal aspect and also the recognition given by the scientific community and esteemed peers. This functions as a reinforcing agent for the original motivation for pursuing research. Our subjects were mostly interested in recognition by the scientific community and esteemed peers. Societal recognition had rather low frequency, and it can be assumed that it is taken for granted as naturally following upon recognition by peers.

Practical applications of contributions to science and responsibility to society come rather low on the list of motivating factors. This is probably due to the subjects in our investigations, mostly drawn from university settings and involved in 'basic research'. But it is reasonable to assume that the applied aspect is in the background during a major part of the research process and becomes timely again at the result and report writing stages.

Financial gains as a motivating factor received the lowest frequency. That pecuniary gains play such a minor role may be due to the responses being coloured by social conventions. It is more reasonable to assume that emoluments play a part in so far as they are necessary to cover the most basic needs valued by scientists, but beyond that money does not play a very important role. Further, scientists, due to their deep preoccupation and interest in their problem, need their mental energy for issues that interest and fascinate them; monetary labyrinths, together with the time and energy they absorb and a lack of personal involvement with them, are of secondary importance. This is supported even when we compare the results with studies of inventors (Rossman, 1963), and innovators in industry (Ekvall, 1971). Another indication that pecuniary interests are of minor impor-

tance is the low frequency of reference to citations, awards and other prestige symbols as motivating factors (cf. McCanney and Edwards, 1972). It is difficult to visualize a creative scientist, or an artist for that matter, sitting at his desk and conducting the following monologue:

I must be very familiar with area X because it is a good hunting ground for discovering new problems. And if I do that, then I shall win the Nobel Prize and everybody will quote me and I shall become famous.

(For the dysfunctional effects of such awards as the Nobel Prize and others see Zuckermann, 1966, where it is shown that decrease in productivity is partly related to awards.)

Motivation and the creative process

The motivational aspects outlined above can also be studied with respect to their role in the creative process. Bearing in mind the phases in the creative process outlined above and the fact that the process can stretch over hours, days, months and even years, one can comprehend the vital role these motivational factors play in the research process of the scientist. The initial phase, through, for example, the 'naïve' asking of questions is characterized by the inception of and increase in the interest for a problem area. The second phase, when the scientist works intensively in an area and is oblivious to his environment, shows commitment and energy investment on the part of the researcher. If hindrances and frustrations, due to the absence of a solution, are met, his deep involvement ensures that he does not leave the problem prematurely but persists in his endeavours. During the third phase, the low-activity period, there is recurrent return to the problem but also preconscious processing in progress. This preconscious treatment can only take place if there is an investment of personal energy and task involvement. During this period the motivational factors play an important role, but their dynamics are still a mystery to us. Yet, it is worth noting that these factors maintain and sustain the interest of the scientist in the problem area.

The need for curiosity and intellectual stimulation carries the scientist through the laborious process of elaboration. This 'perspiration' that follows the 'inspiration' (idea-cognition) can be a most trying period. The immediate delight and feeling of awe (some report it as verging on the religious) at an aesthetically satisfying and simple solution is in itself a motivational factor, as our studies of critical moments have shown. The frustrations and disappointments preceding the cognition of the idea are forgotten and joy over the birth of the idea (cf. also Henle, 1967) motivates continued maintenance of interest and further processing to make it communicable.

Concluding remarks

Most knowledge about individual research work originates from anecdotal information and personal experiences of scientists reported in autobiographies, etc. Such data are valuable for setting up hypotheses for research in the 'psychology of science' and related areas. But the data, in their original form, must be treated with caution, especially in drawing scientific generalizations. The discussion in this article, essentially based upon systematic empirical studies, is a contribution to the structuring of this relatively new field. But much more empirical research is needed, before there is substantial and detailed knowledge of the research process as a whole and the three main areas discussed here: critical moments, the creative process and research motivation.

Our investigations cannot be characterized as teratological, that is to say as relating to exceptionally creative or genial scientists. The subjects were mostly 'ordinary' researchers from university settings and consisted of established researchers, Ph.D.s and Ph.D. candidates. The results of these investigations and what is reported in the autobiographies of eminent scientists, show remarkable similarities and some of the accounts, concerning the importance of informal communications, and low-activity periods preceding the emergence of an idea, can be generalized to 'ordinary' researchers.

According to our results, there seems to be much similarity between scientists of different specializations about what are experienced as the most positive critical moments influencing research work. The results have also, among other things, emphasized the importance of the initial stage in the research process, including the identification and choice of a problem; and the frequent negative effects of the time factor on research work. It does seem that for investigating different factors influencing research work in general and in the various disciplines, the study of critical moments is a fruitful approach.

Our studies have also provided interesting information about research motivation. Intellectual stimulation and need for novelty, described as the most significant motivational factors, should be viewed as rather broad constructs describing an aspect of the complex motivational situation in research. The importance of these motives, their structure and genesis, ought to be the aim of future investigations, as also their role in the creative process in relation to other components of scientific work. The pre-idea and the initial phases seem to be the most interesting parts of the creative process for continued study both from a motivational and cognitive viewpoint.

The methodological problems are, however, very intricate both with respect to the creative process and the individual research process as a whole. It is, for example, often very difficult for an individual to reconstruct and describe in detail the chain of events preceding the cognition of an idea or critical moments that occurred some time back, or even quite recently. In the present state of

knowledge, the best solution to these methodological difficulties is to use several different methods, e.g. different experimental techniques, psychoanalytic association technique, biographical analysis and anamnestic, incidental and longitudinal interviews. The subsequent comparison of the results from such diverse methodologies and techniques should not only increase empirical knowledge but also help in structuring a theory in this field.

References

- ALBERT, R. S. 1969. Genius: present-day status of the concept and its implications for the study of creativity and giftedness. *Am. Psychol.*, vol. 43, p. 743-52.
- BARRON, F. 1968. *Creativity and personal freedom*. New York, N.Y., Van Nostrand.
- BEVERIDGE, W. I. B. 1957. *The art of scientific investigation*. London, Mercury Books.
- CATTELL, R. B. 1963. The personality and motivation of the researcher from measurements of contemporaries and from biography. In: C. W. Taylor and F. Barron (eds.), *Scientific creativity: its recognition and development*. New York, N.Y., Wiley.
- CRANE, D. 1970. The nature of scientific communication and influence. *Int. Soc. Sci. J.*, vol. XXII, no. 1, p. 28-41.
- CRUTCHFIELD, R. S. 1962. Conformity and creative thinking. In: H. E. Gruber, G. Terrel and M. Wertheimer (eds.), *Contemporary approaches to creative thinking*. New York, N.Y., Atherton Press.
- DALENIUS, T.; KARLSSON, G.; MALMQUIST, S. 1970. *Scientists at work: festschrift in honour of Herman Wold*. Stockholm, Almqvist & Wiksell.
- EKSTAM, K. 1968. Kommunikation och produktivitet pa tva forskningsinstitutioner—en allmän översikt [Communication and productivity at two research departments—a general view]. Lund, Department of Psychology. (Mimeo.)
- EKVALL, G. 1971. Creativity at the place of work. A study of suggestors and suggestion systems in the Swedish mechanical industry. Malmö, The Swedish Council for Personnel Administration.
- FLANAGAN, J. C. 1949. *Critical requirements for research personnel*. Pittsburg, American Institute for Research.
- FOX, D. J. 1968. The research process in education. New York, N.Y., Holt, Rinehart & Winston.
- GARVEY, D.; GRIFFITH, C. 1971. Scientific communication. Its role in the conduct of research and creation of knowledge. *Am. Psychol.*, vol. 26, no. 4, p. 349-62.
- GETZELS, J. W.; JACKSON, P. W. 1962. *Creativity and intelligence: explorations with gifted children*. New York, N.Y., Wiley.
- GHISELIN, B. (ed.). 1963. *The creative process*. New York, N.Y., Mentor Books.
- GIOVACCHINI, P. L. 1966. Dreams and the creative process. *Br. J. med. Psychol.*, vol. 39, p. 105-15.
- GREEN, E. I. 1954. Creative thinking in scientific work. *Elect. Enging*, vol. 78, June, p. 489-94.
- GUILFORD, J. P. 1967. *The nature of human intelligence*. New York, N.Y., McGraw-Hill.
- HAEFELE, J. W. 1962. *Creativity and innovation*. New York, N.Y., Reinhold.
- HENLE, M. 1962. The birth and death of ideas. In: H. E. Gruber, G. Terrel and M. Wertheimer (eds.), *Contemporary approaches to creative thinking*. New York, N.Y., Atherton Press.
- HOLTON, G. 1970. Introduction to the issue: 'The making of modern science: biographical studies'. *Daedalus*, vol. 99, no. 4, p. 723-9.
- KOESTLER, A. 1964. *The act of creation*. London, Macmillan.
- KRAGH, U.; SMITH, G. J. W. (eds.) 1970. *Percept-genetic analysis*. Lund, Gleerups.
- KRIS, E. 1964. *Psychoanalytic explorations in art*. New York, N.Y., Schocken.
- KUBIE, L. 1958. *Neurotic distortion of the creative process*. Toronto, Ambassador Books.
- MCCARREY, M. W.; EDWARDS, S. A. 1972. Hierarchies of scientist goal objects: individual characteristics and performance correlates. *J. appl. Psychol.*, vol. 56, no. 3, p. 271.
- MACKINNON, D. W. 1967. The highly effective individual. In: R. L. Mooney and T. A. Razik (eds.), *Explorations in creativity*. New York, N.Y., Harper & Row.
- . 1968. Creativity: psychological aspects. *The international encyclopaedia of social sciences*, New York, N.Y., Macmillan, The Free Press. p. 435-42.

References (continued)

- MADDI, S. R. 1965. Motivational aspects of creativity. *J. Personality*, vol. 33, p. 330-47.
- MAINI, S. M. 1970. The correlates of ideas. Lund, Department of Psychology. (Mimeo.)
- . 1971. Creative and critical moments and processes as reported by a group of 'scientists at work'. Lund, Department of Psychology. (Mimeo.)
- MAINI, S. M.; NORDBECK, B. 1972. Critical moments in research work. A study of research workers in the behavioural sciences. *Psychol. Res. Bull.* (Lund Univ.), vol. 12, no. 10.
- MASLOW, A. H. 1954. *Motivation and personality*. New York, N.Y., Harper & Row.
- NEWELL, A.; SHAW, G. C.; SIMON, H. A. 1962. The processes of creative thinking. In: H. E. Gruber, G. Terrel and M. Wertheimer (eds.), *Contemporary approaches to creative thinking*. New York, N.Y., Atherton Press.
- NORDBECK, B. 1969. Forskaren och forskningens psykologi. Projektbeskrivning. Sammanfattning av gjorda och planerade studier [Psychology of the researcher and research-description of a project. Summary of completed and planned studies]. Lund, Department of Psychology. (Mimeo.)
- . 1971. Problem—what is a problem? *Int. Ass.*, no. 7.
- . 1972. Critical moments and the choice of problems in research work. A study of scientists in biology. Lund, Department of Psychology. (In preparation.)
- NORDBECK, B.; MAINI, S. M. 1970a. Psychology of the researcher and research: critical moments and processes in research work. Project progress report—Part I. *Psychol. Res. Bull.* (Lund Univ.), vol. 10, no. 11.
- . 1970b. Psychology of the researcher and research: Studies in the selection of potential researchers. Project progress report—Part II. *Psychol. Res. Bull.* (Lund Univ.), vol. 10, no. 12.
- OLBY, R. 1970. Francis Crick, DNA, and the central dogma. *Daedalus*, vol. 99, no. 4, p. 938-87.
- PATRICK, C. 1935. Creative thought in poets. *Archs Psychol.*, no. 178.
- . 1938. Scientific thought. *J. Psychol.*, vol. 5, p. 55-83.
- PELZ, D.; ANDREWS, F. M. 1966. *Scientists in organizations*. New York, N.Y., Wiley.
- RAPAPORT, D. 1965. Toward a theory of thinking. In: D. Rapaport (ed.), *Organization and pathology of thought*.
- ROE, A. 1953. *The making of a scientist*. New York, N.Y., Dodd Mead.
- ROSSMAN, I. 1963. *Industrial creativity. The psychology of the inventor*. New York, N.Y., University Books.
- SINGER, B. F. 1971. Toward a psychology of science. *Am. Psychol.*, vol. 26, no. 11, p. 1010-15.
- STANKIEWICZ, R. 1968. The role of informal communication in integration and coordination of research. *Comm. Res. Econ.* (Stockholm), no. 37.
- SZÉKELY, L. 1967. The creative pause. *Int. J. Psychoanal.*, vol. 48, pt 3.
- TAYLOR, C. W. (ed.). 1964. *Creativity: progress and potential*. New York, N.Y. McGraw-Hill.
- TAYLOR, C. W.; HOLLAND, J. 1964. Predictors of creative performance. In: C. W. Taylor (ed.), *Creativity: progress and potential*. New York, N.Y., McGraw-Hill.
- TAYLOR, C. W.; SMITH, W. R.; GHISELIN, B. 1963. The creative and other contributions of one sample of research scientists. In: C. W. Taylor and F. Barron (eds.), *Scientific creativity: its recognition and development*. New York, N.Y., Wiley.
- WALLAS, G. 1926. *The art of thought*. New York, N.Y., Harcourt Brace.
- WATSON, J. D. 1968. *The double helix. A personal account of the discovery of DNA*. London, Weidenfeld & Nicolson.
- ZUCKERMAN, H. 1966. Nobel laureates in science: patterns of productivity, collaboration and authorship. New York, N.Y., Columbia University. (Mimeo.)

PERSONALITY AND COGNITIVE DIFFERENCES BETWEEN AN ORIGINAL AND A NON-ORIGINAL GROUP¹

S. M. MAINI

Lund University, Sweden

Summary.—From 66 high school students studied, an original ($n = 19$), and a non-original ($n = 25$) group was chosen on the basis of two originality measures extracted from the Utility and Gestalt Completion Tests. As predicted, the original group, when compared with the non-original group, was more fluent, less rigid and less stimulus bound. The group also showed itself to be Tolerant of Ambiguity, low on Social Desirability and capable of adaptive regression in the service of the ego. The results were discussed in terms of an Objective-Subjective continuum, the objective side being more stimulus bound, rigid, and lacking in adaptive regression. The original group was more proximal to the subjective end of the continuum and capable of momentary and partially controlled regression which served a constructive and creative function.

In a previous study (Jern & Maini, 1971) the personality and attitude correlates of certain "creativity" or divergent type of tests were assessed. The basic model employed for interpreting the results consisted of a continuum between an "Objective" and a "Subjective" pole. The objective end represented that which is concrete and observable, and thereby capable of summoning a communality of agreement through the corroboration of other individuals in the environment. The subjective pole was designated as implying purely idiographic and non-veridical behaviour, i.e., not perceived by others in the environment and thus lacking in a consensus of agreement. The "objective" oriented individual is characterized by a secondary process or convergent type of thinking, and the "subjective" one by primary process or divergent type of thinking.

Since the chief characteristics of a creative personality are well summarized elsewhere (e.g., Golan, 1963; Dellas & Gaier, 1970), it is sufficient to note that such persons are autonomous and independent, are largely withdrawn and inner directed, sensitive, imaginative, and intuitive. The cognitive correlates are flexibility, fluency, and tolerance of ambiguity, complexity, and perceptual novelty. These personality and cognitive qualities of the creative person indicate their proximity to the subjective end of the continuum defined above. It is, of course, quite correct that the psychotic type would also converge towards the subjective pole, but he would be a 'prisoner of the subjective pole' without the ability to maintain a reality contact (cf. Kris, 1964). And similarly, the rigid and non-flexible person would adhere to the objective pole and thus give priority to secondary process type of thinking with strong cognitive control. The strength

¹The present study was supported by a grant from the Tri-Centennial Fund of the Bank of Sweden (*Psychol. Res. Bull.*, 1973, 13, No. 1).

of the creative person lies in his ability to maintain a balance between the two extreme poles, but with the ability to "regress in the service of the ego" when the need arises.

With reference to this discussion and as a follow-up to the previous study, the present work was primarily aimed at further exploring the Subjective-Objective continuum. This was to be done by choosing two extreme groups, one supposedly more object bound, i.e., a non-original group, and the other more subject bound, i.e., an original group. The two groups were to be chosen on the basis of their performance on the Utility and the Gestalt Completion Tests. The major prediction was that the extreme groups would show significant differences on such variables as tolerance of ambiguity, fluency, and rigidity.

METHOD

Subjects

The volunteers were 66 high school (Swedish gymnasium) students. They received a nominal remuneration for participation. The mean age of the group was 18 yr. (ranging in age from 17 to 21 yr.). There were 37 females and 29 males.

Instruments

The instruments were given in the order presented below. The total testing time was 1 hr. and Ss were tested in groups of 10 to 15.

Gestalt Completion Test: (15 min).—A previous version of the test (Jern & Maini, 1971) consisted of 15 incomplete "Street" type pictures. Each picture is a relatively unorganized or mutilated figure in a seemingly unorganized field. Five pictures were used in the present study. These pictures were found (Larsson, 1972) to elicit many responses and at the same time have high discrimination power. The new version was tried out by the present author with 20 students attending evening classes, and the results proved satisfactory. The 5 incomplete pictures in the new shorter version are printed on a large sheet of paper and S is requested to provide as many communicable interpretations, of each picture, as possible, and also to use his imagination. S is free to interpret the pictures in any order he wishes. Several variables are scored.

Stimulus-bound responses are interpretations credited with points (0-3), according to a manual developed previously. It is the degree of agreement with the stimulus motif that is accredited with points. An interpretation receives 3 points if the following criteria are fulfilled: (a) All the dark patches are taken into account in the interpretation. (b) All the patches (both light and dark) are considered as parts of a complete picture, i.e., Gestalt responses. (c) Good agreement between the interpretation and the stimulus picture, as rated by a group of experts.

Subjects receive 1 or 2 points if all the above criteria are not met. But to

receive 1 or 2 points it is necessary that the responses can be validated, i.e., the said interpretation can be seen by others, either with experience in the analysis of the test or given time to observe the picture. Thus scored, total number of points, the variable is defined as measuring the ability to integrate and interpret incomplete visual/figural information and obtain an impression of the whole from the various parts of the picture. The originals were expected to be less stimulus bound than the non-originals.

Fluency is defined as the total number of responses, excluding repetitions, irrespective of their closeness to the picture motif or degree of communicability, i.e., if others can see the same or a similar interpretation. This variable involves more of "divergent" thinking ability than the foregoing (stimulus-bound), which is more of the "convergent" type (cf. Guilford, 1967).

Stimulus-free Responses are not credited with any points, i.e., interpretations according to the manual and the above mentioned criteria, having none or very little correspondence with the picture. The originals were expected to give more stimulus-free responses and be more fluent than the non-originals.

Regressive Responses are incomplete and so-called "vulgar" responses, which can be given to all the pictures, e.g., modern art, ink-blots, photo-negative, hieroglyphic, and aerial view. Regressive responses and the originality scores just to be described were used in some other investigations (Nordbeck, B. U., 1965; Nordbeck, B. M., 1971) and had provided a number of promising results. As this form of regression is not adaptive, i.e., non-integrative, the originals were expected to have low scores on this variable.

For an *Originality score* the main criterion was that the interpretation was not given by others in the present or past investigations (checked against the manual). A further demand was that the responses covered at least one-half to two-thirds of the picture. Regressive responses were not included here. Thus, the originality score was the number of interpretations being statistically infrequent and incorporating one-half to two-thirds of the picture. It is to be noted that the criteria for originality are more strict here than the ones used for obtaining the originality score on the Utility Test (see below).

In the *Test of Fantasy* Ss were shown the classical film used by Heider and Simmel (1944) to study, among other things, stimulus configurations. In this 2½-min. film, three geometrical figures (a large red triangle, a small blue triangle, and a green circle) were shown moving in various directions and at various speeds. The only other figure was a rectangle, a section of which could be opened and closed as a door. Ss were instructed to describe and write down what happened in the film and to feel free to use their fantasy. They were also required to give a title to their description. The film was shown twice, with an interval of approximately 2 min.

Ss were told that they had approximately 15 min. in which to write down their descriptions. This approximate time-limit was arrived at through a pilot

study conducted with 10 Ss, where the time was varied between 10 and 25 min. During the present investigation most Ss finished within the time-limit, and the few who took longer time were free to carry on until they had finished. The aim was, among other things, to provide stimuli with more task-involvement than is normally the case, e.g., Brick uses (cf. Taft, 1971). The variable of primary interest in the present investigation was *Word Fluency*, which is a count of the total number of words, excluding the title, used in the description. This variable was chosen because of the need for an independent measure of fluency. As on the Gestalt Completion fluency, the originals were expected to be more fluent, both on this and the following fluency (Utilities) measure.

Non-verbal Rigidity is a short, non-verbal test for measuring rigidity. Breskin (1968) says that it is based on the assumption that "a more rigid person, given the opportunity to express a preference between pairs of figures differing only in 'goodness of fit,' will tend to select the 'better fit'" (p. 1204). Better fit applies to one of the figures in each pair which closely follows the "Gestalt course" and which does not transgress the laws of "Prägnanz." S is required to express a preference for each of 15 pairs of figures. The response to each is scored either 1 (indicating a preference for the figure which is a 'good fit') or 0 (indicating a preference for the figure which is not a 'good fit'). The maximum rigidity score is 15, while the minimum is 0. Based on the results obtained by Gorman and Breskin (1969), this variable is considered as being more characteristic of the non-originals than the originals.

On the *Utility Test* (10 min.) Ss were required to list as many uses as they could think of for a brick. This is a widely used method to test *Fluency*, defined as the total number of valid responses given, and *Originality*, defined as statistical infrequency of the responses. While calculating the fluency score, repetitions of the same theme or use were considered invalid, and the originality score consisted of responses which occurred less than 1% of the time in the group being investigated.

A previous version of the *Personality Inventory: Opinions, Attitudes and Personality* had 10 subscales (Jern & Maini, 1971). Only four of the subscales were chosen. The items were randomly distributed in the whole inventory and care was taken to balance the items. The four subscales are: (1) Regression in the Service of the Ego (29 items), (2) Tolerance of Ambiguity (14 items), (3) Social Desirability (33 items), (4) Extraversion (6 items). It was expected that the originals would be able to regress in the service of the ego and be more tolerant of ambiguity. They would also be low on social desirability and extraversion.

RESULTS

The Whole Group

Significant sex differences ($P < 0.05$, two-tailed t test), with the males scoring higher, were observed for the variables of Extraversion (personality in-

TABLE 1
PRODUCT-MOMENT CORRELATIONS BETWEEN TEST AND PERSONALITY VARIABLES ($n = 66$)

Variables	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Regression in the Service of Ego	19.61	4.08		199	137	-236	045	106	164	-011	209	192	062	-260	321
2. Tolerance of Ambiguity	7.05	2.12			129	090	002	000	028	-036	158	084	-015	-153	308
3. Extraversion	4.17	1.43				-140	088	018	107	-052	187	001	063	-102	-123
4. Social Desirability	12.09	5.52					118	-243	-163	-120	-103	-113	-136	147	-245
5. Stimulus Bound (Gestalt)	9.70	3.96						-309	087	-391	-118	012	-039	-027	140
6. Stimulus Free (Gestalt)	7.42	5.50							890	743	180	285	176	-286	060
7. Fluency (Gestalt)	12.35	4.34								617	178	263	152	-319	056
8. Regression (Gestalt)	2.82	3.54									-139	200	062	-074	-053
9. Originality (Gestalt)	1.09	1.09										097	239	-092	-019
10. Fluency (Utility)	15.38	6.08											589	-001	159
11. Originality (Utility)	0.73	1.52												-054	-030
12. Non-verbal Rigidity	8.12	3.34													-047
13. Fluency (Fantasy)	160.79	57.18													

Note.—Decimal points omitted.

For $N = 66$, $p = 0.05$ at $r = 0.201$; $p = 0.01$ at $r = 0.282$ (one-tailed). For $N = 66$, $p = 0.05$ at $r = 0.239$; $p = 0.01$ at $r = 0.312$ (two-tailed).

ventory) and Fluency (utility test). Tests of significance were also conducted within the two extreme groups. In the Original group (9 males and 10 females), the males were significantly higher on Extraversion only. In the Non-original group (6 males and 9 females), males were higher only on Fluency (utility).

The Pearsonian correlations in Table 1, based on the total sample, show a pattern similar to the one obtained previously. But in general the values are lower than prior ones. This can partly be ascribed to the present group studied, high school students, while in the other study Ss were university students and partly because of regression to the mean found in replications of earlier studies.

Non-verbal rigidity and the rest of the variables show negative and expected correlations. And the same pattern emerges for the Social Desirability variable. The fantasy measure does not show any strong relationships with the other two fluency variables. Fantasy probably has a higher loading on S's vocabulary than the other two fluency measures. But at the same time fantasy fluency does show significant correlations with the questionnaire measures of Regression, Ambiguity and Social Desirability (negative correlation). This instrument will be studied further. The two originality measures (Utility and Gestalt Completion) show a low but significant correlation which could be due to the different stimuli used to elicit the responses from Ss, and the differences in the criteria used for the two measures.

The high correlations between the Gestalt variables: Stimulus Free, Fluency, and Regression, are partly inflated because the measures belong to the same test and because of their inter-dependence upon each other. Gestalt Regression shows low but negative correlations with rest of the variables. This form of regression can be termed as non-adaptive in contrast to the questionnaire measure of Regression in the Service of the Ego.

Extreme Group Comparisons

The two extreme groups were selected on the basis of Ss' score on the two originality measures. This strict criterion was used so as to have only such Ss as displayed originality in more than one situation and thus reducing chance selection to a minimum. The original group included 19 Ss who had at least one original response on the Gestalt and another one on the Utility Test. The non-original group of 15 Ss was original on neither test.

Table 2 shows that the mean differences between the groups are in the expected direction. Besides the significant differences, there are four variables showing non-significant differences in the predicted direction. It is worth noting that the Gestalt Regression variable has a higher mean in the Non-original group than in the Original group, and the correlation table (Table 1) would have been misleading if the interpretation of the results had been restricted to it only because of the significant positive correlations with the Fluency variables and the negative one with Gestalt Stimulus Bound and Social Desirability

TABLE 2
DIFFERENCES IN MEANS BETWEEN ORIGINAL ($n = 19$) AND
NON-ORIGINAL ($n = 15$) GROUPS

Variable	Original Group		Non-original Group		$M_{diff.}$	t	$p^\dagger$
	M	SD	M	SD			
Regression in Service of Ego	20.89	3.38	18.47	3.78	2.43	1.97	.05
Tolerance of Ambiguity	7.68	2.98	5.80	2.11	1.88	2.06	.02
Extraversion	4.31	1.29	4.20	1.47	.12	.24	
Social Desirability	9.68	3.62	13.47	6.33	-3.78	2.19	.02
Stimulus Bound (Gestalt)	9.21	2.25	11.73	4.33	-2.52	2.19	.02
Stimulus Free (Gestalt)	7.63	3.90	5.47	3.38	2.17	1.70	.05
Fluency (Gestalt)	12.16	4.26	11.07	3.77	1.09	.78	
Regression (Gestalt)	1.37	1.95	2.27	2.69	-0.90	1.13	
Fluency (Utility)	18.57	6.95	13.33	6.27	5.25	2.28	.02
Non-verbal Rigidity	8.05	2.78	9.33	4.20	-1.28	1.06	
Fluency (Fantasy)	180.84	64.26	156.80	54.07	24.04	1.16	

† One-tailed for 32 df .

variables. Characteristic of the originals is not non-adaptive regression but, on the contrary, the ability to regress and maintain a contact with reality.

Fluency in Fantasy, though not significant, shows a difference in the expected direction. It is worth noting that Gestalt Fluency does not show as marked a difference as the Utility fluency measure, even though the difference is in the predicted direction. The only variable with a small mean difference is Extraversion. This could partly be a function of the restricted number of items (six) used to tap this aspect of personality.

DISCUSSION

The major aim was to investigate personality and cognitive differences between an original and a non-original group. The results substantiated the predictions and one can summarize the original group as being non-rigid, tolerant of ambiguity, low on social desirability, and possessing the ability momentarily, and at least partially to make controlled use of primitive, non-logical and drive motivated modes of thinking through their ability to regress in the service of the ego. These cognitive and personality characteristics thus make the group more fluent and less stimulus bound, i.e., they are capable of "increasing the distance" (Rapaport, 1962) from the stimulus motif.

Several investigators (e.g., Pine & Holt, 1960; Gamble & Kellner, 1968) have studied the psychoanalytic concept of 'regression in the service of the ego' and tested it with the help of, e.g., projective techniques and the Stroop Colour Word Test. They succeeded in showing that a creative S is capable of adaptive regression and thus has access to the preconscious processes, a necessary prerequisite for creative production (see, e.g., Maini, 1971; Maini & Nordbeck, 1973).

In the present investigation there was one measure of maladaptive regression. This variable characterized the non-original group and the difference in means was in the expected direction. (It is to be noted that an adaptive form of regression characterized the original group.) The empirical test of maladaptive regression (operationalized through the non-integrative responses on the Gestalt Completion) is based on the assumption that the perceptual function of integrating the picture calls for functions appearing early in the development, while the verbalization is dependent upon functions which are developmentally advanced. This rationale is based on the theoretical premises of Piaget (Flavel, 1963), and the percept-genetic theory (Kragh & Smith, 1971). Perceptual integration needs to be co-ordinated and linked with abstract conceptualization and when these attempts are unsuccessful, *S* takes recourse to a maladaptive form of regression. These unsuccessful attempts result in the so-called "vulgar" responses which are at a low level of abstraction and also applicable to several picture motifs which present different Gestalt configurations. These responses are thus non-integrative and thereby incongruous attempts to create an integrated perceptual/conceptual impression which is unique to a particular stimulus motif.

Speculating on the strength of the above rationale and the results obtained, it is both parsimonious and coherent to place the non-original group nearer the Objective end of the continuum, with the pattern of rigid secondary process type of thinking as its major characteristic. But when such thinking relaxes its controls, the regression is total and *S* founders in the non-logical primary process type of thinking without the necessary and crucial ability of utilizing this regression in a constructive, creative and adaptive manner. The original group, on the contrary, while being more proximal to the subjective end of the continuum, is capable of momentary and partially controlled regression which serves a constructive and creative function. Viewed from the frame of reference of this study, an interesting hypothesis for a future study would be to investigate the relationship between, e.g., originality and subjectivity (as defined in this study).

Finally, a word of caution regarding creative thinking may be added here. This refers to the distinction between the two types of thinking involved at the extremes of the continuum. Creative functioning requires both types of thinking. On the one hand, it involves the capacity to suspend convergent or logical considerations temporarily and thus facilitate "subjective," novel and perhaps unorthodox thinking. On the other hand, it involves the strength to stop this regressive mode of functioning, and the ability to revert to more logical and "objective" ways where realistic and appropriate contexts are provided for the original and novel ideas.

REFERENCES

- BRESKIN, S. Measurement of rigidity, a non-verbal test. *Percept. mot. Skills*, 1968, 27, 1203-1206.

- DELLAS, M., & GAIER, E. L. Identification of creativity: the individual. *Psychol. Bull.*, 1970, 73, 55-73.
- FLAVEL, J. H. *The developmental psychology of Jean Piaget*. New York: Van Nostrand, 1963.
- GAMBLE, K. R., & KELLNER, H. Creative functions and cognitive regression. *J. Pers. soc. Psychol.*, 1968, 9, 266-271.
- GOLAN, S. E. Psychological study of creativity. *Psychol. Bull.*, 1963, 60, 548-565.
- GORMAN, B. S., & BRESKIN, S. Non-verbal rigidity, creativity, and problem solving. *Percept. mot. Skills*, 1969, 29, 715-718.
- GUILFORD, J. P. *The nature of human intelligence*. New York: McGraw-Hill, 1967.
- HEIDER, F., & SIMMEL, M. An experimental study of apparent behaviour. *Amer. J. Psychol.*, 1944, 57, 243-259.
- JERN, S., & MAINI, S. M. An interpretation of utility, Gestalt completion and personality variables on the continuum of objectivity-subjectivity. *Psychol. Res. Bull.*, 1971, Lund Univer., 11, No. 12.
- KRAGH, U., & SMITH, G. J. W. *Percept-genetic analysis*. Lund: Gleerup, 1970.
- KRIS, E. *Psychoanalytic explorations in art*. New York: Schocken Books, 1964.
- LARSSON, L.-A. *Gestaltkompletteringstestet; Beskrivning och omarbetning av ett forskningsinstrument*. Lund: Dept. of Psychol., 1972.
- MAINI, S. M. *Creative and critical moments as reported by a group of "Scientists at Work."* Lund: Dept. of Psychol., 1971.
- MAINI, S. M., & NORDBECK, B. Critical moments, the creative process and research motivation. *Int. soc. Sci. J.*, in press.
- NORDBECK, B. M. *En studie av förmågan att integrera ofullständig information med hjälp av ett Gestaltkompletteringstest (GKT)*. Lund: Dept. of Psychol., 1971.
- NORDBECK, B. U. *Cognitive age differences*. Lund: Dept. of Psychol., 1960.
- PINE, F., & HOLT, R. R. Creativity and primary process: a study of adaptive regression. *J. abnorm. soc. Psychol.*, 1960, 61, 370-379.
- RAPAPORT, D. Projective techniques and the theory of thinking. *J. Proj. Techn.*, 1952, 16, 269-275.
- TAFT, R. Creativity: hot and cold. *J. Pers.*, 1971, 39, 345-361.

Accepted July 2, 1973.

Cognitive Restructuring as Reflected in an Experimental
Problem-Solving Situation and the Gestalt Completion Test

by S.M. Maini

To be published in the Psychological Research Bulletin 1981

A b s t r a c t. - Studied, in a pilot investigation with students, responses to three problem solving tasks. Three further studies on the finally selected task, the "Hatrack" problem are reported. The subjects in the first two studies were students and in the third researchers. Success in the solution of the problem is related to the level of active investigatory behaviour involving all of the stimulus material. The three studies also show consistent results on the Regressive variable in the Gestalt Completion Test, subjects with regressive responses being less able to solve the problem.

In the third study certain conclusions are drawn about the similarities between the experimental problem and phases in the research process as reported by the researchers in an interview. The phases are apparatus construction, field work and experimental laboratory work. The researchers successful in solving the problem could be characterized as desiring variety, regarding the data-gathering stage as tedious, and impatient to see the results of their personal research endeavours.

Intelligence, broadly defined as attempts at adaptation (in the Piagetian sense), implies the functioning of the twin processes of assimilation and accommodation and the reaching of an equilibrium between the individual and the environment. Each process can pre-dominate and they may alternate in the actual process of adaptation. A conservative aspect of intelligence is seen in the attempts of individuals to look for familiar patterns in new situations. These attempts, reflecting an assimilatory activity, often consist of ignoring or erasing any "existing deviations" (cf Raaheim, 1974) and thus may prevent the individual from discovering that a radical change is exigent for coping with the situation. This is applicable, among other things, to problem situations requiring accommodatory activity. The initial assimilatory functioning of the individual in novel or problem solving situations could be due to the challenging nature of the problem or the anxiety provoked by the novelty.

A variety of situations require more "creative" solutions for facilitating the process of adaptation, e.g. research settings and artistic production. It would be correct to surmise that "creative" solutions require restructuring and re-organization (cf Kragh & Smith, 1974), and this is the other, more laborious side of intelligence relying much more on the accommodatory process during certain phases in the process of adaptation.

The research so far conducted by the author has as its broad aim to study the researcher and the research process, i.e. "logic in process" and not "reconstructed logic" as reported in text-books and research reports (Nordbeck & Maini, 1970). These initial attempts led to the observation and study of certain categories of critical moments in the research process (Maini & Nordbeck, 1973); and pin-pointed, among other things, the constant attempts of the researchers to "solve problems" and to arrive at "new" and "original" solutions to the broad research problems or the routine type of activities in the process of research (cf the broad definition of intelligence and the distinction above).

The problem solving activities in the process of research were often brought to the fore in our interviews with the researchers and we have research data, of a descriptive nature, about this from interviews (Nordbeck, 1975), questionnaires (Maini & Nordbeck, 1972) and biographies (Maini, 1971). Attempts to analyze the implications of the concept of "problem" (cf Nordbeck, 1971) gave some clarity at a conceptual level, but it was deemed necessary to study the problem solving process under strict laboratory conditions. For this a "suitable" problem had to be found. Suitable in the sense that it would give insight into the "creative" aspects of the problem solving process.

The field of "problem solving" is replete with tasks and problems that make the study of related behaviour under strict laboratory conditions possible. But most of the problems can be characterized as requiring the use of assimilatory activities, i.e. the subjects can look for familiar patterns in the new situation and thereby solve the problem. A problem was needed that involved insight and

required re-structuring (accommodatory activity). Besides, the problem should also shed light on the process of research and be sufficiently stimulating and meaningful for a group of scientists.

The present investigation reports a pilot study for the choice of a problem, two studies testing the expediency of the chosen problem and a third one with researchers. The three studies also search for possible relations between the problem and certain personality and cognitive variables. The third study also attempts to describe the correspondence between the chosen problem and the process of research.

THE PILOT STUDY

This was conducted with 31 subjects, tested in groups of 3-5 individuals. Three problems were presented on separate sheets of paper, following the descriptions by, among others, Raaheim (1974); each paper also carried an illustrative drawing of the situation. The order of presentation was varied and time taken when the subject had solved the problem.

The Pea Problem

All the peas in the glass jar on table (A) are to be transferred into another jar of the same size on another table (B). The distance between the table centres is two meters. The transferring of the peas is to be done from behind table (A), and "you are not allowed to move the tables or throw the peas. The aim is to find a fast and safe method of solving the problem, and you can have whatever you need to solve it".

The Two-string Problem

Two lengths of string are hanging down from the ceiling. The distance between them is too great to make it possible to hold one piece of string and reach out for the other one. "How would you tie the strings together?"

The Hatrack Problem

Referring to the drawing of a room, the following was described: "the figure illustrates a room that is 6 meters long, 5 meters broad and 3 meters high. You have two sticks (each 2 meters long) and a so called C-clamp. You are to make a construction, for hanging a heavy overcoat, at the cross on the floor. The construction has to be built with the help of the sticks, which are not to be sawn, and the C-clamp. The construction ought to be stable". (The subjects were shown the sticks and the clamp).

R e s u l t s a n d d i s c u s s i o n

The Pea Problem was solved by all the subjects during the first five minutes ($m = 2.6$ minutes). The Two-string Problem was already known to most of the subjects and the remaining few ($n = 5$) also solved it during the first five minutes. The Hatrack Problem was the one that proved difficult for the subjects. Only five subjects managed to solve it within the first 5 minutes. This agrees with the results presented in some previous studies (Raaheim, 1974; Maier, 1966). Those who could not solve the problem during the first five minutes were given the following hint: "think about the constructions used by window cleaners". After this 4 more subjects solved the problem ($m = 7.0$ minutes). It seems that this hint could not be incorporated into the ongoing approaches adopted by the subjects. Due to its ambiguous nature, it was easy for them to ignore it. A further hint, after 10 minutes, was given: "think of using the floor and the ceiling". This served as a stimulant and 17 of the remaining subjects could solve the problem. It seems that the hint about the ceiling is the best one and this agrees with the work of Burke et al (1966). One of the aims in giving the hints was to test for a suitable cue for a future study.

As the presentation order was varied, we looked for possible effects on the Hatrack problem. No such systematic effect were noted.

For the purposes of the present study, the results noted above led to the choice of the Hatrack Problem. In agreement with Raaheim (1974) it can be concluded that the first two problems reflect the subjects' structuring of a familiar pattern by means of some elements which must be used in unusual ways, and that the Hatrack problem demands the creation of a new structure, where the elements enter with no transformation of their usual functions as far as the subject is concerned. Thus the Hatrack problem may be regarded as necessitating inventive behaviour for its successful mastery. "Inventive" is here defined as the creation of new and free combinations (restructuring) which are not in consciousness

at a certain point in time. The known elements are combined in a way that is novel for the individual (an Aha'-experience).

MAIN STUDY

M e t h o d

Subjects

Study_I

Thirty-three female student volunteers attending an introductory course in Psychology took part in this study. They received a nominal remuneration. Their average age was 26 years.

Study_II

The subjects were 25 male student volunteers (average age = 19 years attending the Swedish "Gymnasium" and they received a nominal remuneration.

Study_III

The 14 subjects were university researchers in the natural sciences. Their average age was 32 years. Their average research experience was 6 1/2 years. The fifteenth subject was the only female in this study and her results are not included.

Instruments

The Hatrack problem was followed by the tests in the order presented below. In studies II and III the personality inventory was deleted. In study III the interview followed the Hatrack problem and the Gestalt Completion Test was administered last.

The Hatrack Problem

Each subject was asked to make a structure sufficiently stable to hang a heavy overcoat (shown to the subject) using only two sticks and an adjustable C-clamp (the sticks measured 2 cm x 3 cm x 160 cm and 2 cm x 3 cm x 145 cm). The C-clamp was so wide that the two sticks could be inserted and held securely with the clamp tightened. The functioning of the clamp was demonstrated to the subject. After this the clamp and the sticks were placed on the floor near the heavy overcoat. The Hatrack was to be built at a point approximately at the center of the room (marked by a cross). The room was empty except for some permanent fixtures - the heating pipes in the ceiling, the lamp etc. The only stable solution to the problem consists of clamping the two sticks together so that they can be wedged between the floor and the ceiling. The clamp handle functions as the hook on which to hang the coat.

The experiment was terminated after 15 minutes. The time limit was based on the results of the pilot study and the work of Burke & Maier (1965). They report that most of the solutions are produced within the first 10 minutes and that few occur after 15 minutes. Thus a 15 minute time limit would be adequate for deter-

mining whether the subjects could solve the problem or not.

The experimenter sat in an adjoining room with the door open and could observe the behaviour of the subjects. The following was noted on an observation sheet:

1. Level of Activity with the clamp: Each time the subjects brought the two sticks and the clamp together was scored as one trial (cf Raaheim, 1974).
2. Level of Activity without the clamp: Each time the sticks were brought together without the clamp being used. The clamp was ignored.
3. Time: A mark was made in the observation sheet every 2 minutes.
4. Motor Level: This variable was not originally noted, but during the first study (I) an interesting detail seemed to emerge. It was that some subjects sat on the floor or on their knees and became in a sense "earth bound". These subjects did not solve the problem. Thus it was decided to make a note of the bodily positions of the subjects during their problem solving attempts - standing, sitting on knees or leaning against the wall.

The Gestalt Completion Test

Five incomplete pictures, printed on separate cards, are placed before the subject and he is requested to write down as many communicable interpretations of each picture as possible and also to use his imagination. The subject is free to interpret the pictures in any order he wished. The total time is 15 minutes. The variables scored are:

Stimulus Bound Responses: These consist of interpretations credited with points (0-3), according to a manual developed in some previous studies. It is the degree of agreement with the stimulus motif that is credited with points. An interpretation receives 3 points if the following criteria are fulfilled:

- a) All the dark patches are taken into account in the interpretation.
- b) All the patches (both black and light) are considered as parts of a complete picture, i.e. Gestalt responses.
- c) Good agreement between the interpretations and the stimulus picture, as rated by a group of experts.

The subjects receive 1-2 points if all the above criteria are not met. But to receive these it is necessary that the responses can be validated, i.e. the said interpretation can be seen by others, either with experience in the analysis of the test or given time to observe the pictures. Thus scored, the variable (total number of points) is defined as measuring the ability to integrate and interpret incomplete visual/figural information and obtain an impression of the whole from the various parts of the picture.

Fluency: Here defined as the total number of responses, excluding repetitions, irrespective of their closeness to the picture motif or communicability, i.e. if others can see the same or a similar interpretation. This variable involves more of "Divergent" thinking ability than the foregoing (Stimulus Bound) which is more of the "Convergent" type (cf Guilford, 1967).

Regressive Responses: Incomplete and so called "vulgar" or "stereotyped" responses, which can be given to all the pictures, e.g. modern art, ink-blot, photo-negative, hieroglyphic, and aerial view. This variable has previously been shown to reflect a maladaptive form of regression, and non-solvers were expected to show this type of behaviour.

Personality Inventory

Opinions, Attitudes, and Personality (OAP). The present version consists of 4 subscales (for further details see Maini, 1973) and was used in Study I only:

1. Regression in the Service of the Ego (29 items).
2. Tolerance of Ambiguity (14 items).
3. Social Desirability (33 items).
4. Extraversion (6 items).

Research process interview

A half-structured interview to probe the following:

- a) If the subjects could see any similarities between the Hatrack Problem and their research in general.
- b) Specific probing of similarities with respect to the phases in the research-process. The phases were to be mentioned if the subjects needed some prompting. The phases were called problem formulation and identification, apparatus construction, data-gathering, analysis of data and reporting (informal or formal publication). (cf Nordbeck & Maini, 1972).
- c) Motivational aspects related to the problem and situations in the research process.

R e s u l t s

The result in Table 1 show that in study I 6 subjects (one subject who solved the problem nearly immediately is not included), in study II 8 subjects (one immediately solved not included) and in study III 4 subjects solved the problem within the stipulated time limit of 15 minutes. Of the 26 non-solvers in study I one subject refused to carry on, while in study II 16 subjects and in study III 10 subjects could not solve the problem.

The average times for the solvers in the three studies were:

8.5 minutes, 7.4 minutes and 8.0 minutes.

The Point-biserial correlations between problem solving and level of activity with the C-clamp for the first 8 minutes were:

0.45 (study I), 0.77 (study II) and 0.67 (study III).

The results in the three studies are generally in agreement with those reported by Raaheim and others who have used the Hatrack problem in various studies. This is true with respect to the C-clamp activity variable, and the Point-biserial correlations, significant in the three studies, between the level of activity with the clamp and problem solving. The time-limit of 15 minutes was ample in view of the average solving time of 8 minutes.

Some interesting results are to be noted with respect to the no C-clamp activity variable. The non-solvers show significantly higher means than the solvers, except in study III. Furthermore, the correlations between the two measures of level of activity

Table 1

were low and insignificant. It seems that the non-solvers cannot retain all the 4 elements (the two sticks, the C-clamp, and the cross on the floor) simultaneously and generally work with only the two sticks and the cross, which decreases the probability of solving the problem. Whenever they used the clamp the cross on the floor was ignored. During the process of solving the problem, the non-solvers, more often, gave an impression of "contemplative activity", i.e. all observable behavioural activity was at a stand-still. It seems that an experimenting and active approach (reflected in the level of activity with the C-clamp) is replaced by abstract overtures not anchored in the reality of the problem. The cognitive strings that connect the two are rather strained. In a way this seems to be an extension, a regressive one perforce, of the not C-clamp activity level.

Table 1. Comparison between solvers and non-solvers on the activity variables.

Problem-solvers			Non-solvers		mean diff.	t-value
m	s		m	s		
Study I						
Level of activity with C-clamp						
a. 0- 2 minutes	2.17	1.60	0.72	0.54	1.45	3.84
b. 0- 8 "	4.50	2.81	2.52	1.08	1.98	2.85
c. 0-15 "	5.00	3.41	3.76	1.36	1.24	1.45
Level of activity without C-clamp						
a. 0- 2 minutes	0.17	0.41	1.24	1.20	-1.07	2.14
b. 0- 8 "	1.33	1.37	2.88	1.73	-1.55	2.02
c. 0-15 "	1.67	1.51	4.84	2.79	-3.17	2.67
Study II						
Level of activity with C-clamp						
a. 0- 2 minutes	1.88	0.64	1.19	0.74	0.69	2.21
b. 0- 8 "	5.63	1.69	3.00	1.21	2.63	4.39
c. 0-15 "	6.50	2.07	4.31	1.74	2.19	2.73
Level of activity without C-clamp						
a. 0- 2 minutes	1.13	0.83	1.63	1.50	-0.50	0.87
b. 0- 8 "	3.88	2.23	4.63	2.39	-0.70	0.74
c. 0-15 "	4.75	3.37	8.63	4.47	-3.88	2.16
Study III						
Level of activity with C-clamp						
a. 0- 2 minutes	1.75	0.43	0.70	0.46	1.05	3.64
b. 0- 8 "	7.50	3.28	2.00	0.78	5.50	4.60
c. 0-15 "	8.00	4.08	2.80	1.84	5.20	3.88
Level of activity without C-clamp						
a. 0- 2 minutes	1.25	0.43	1.30	0.78	-0.05	0.11
b. 0- 8 "	3.50	1.80	4.70	3.10	-0.40	0.67
c. 0-15 "	4.50	3.87	7.80	4.39	-3.30	1.31

Note: 1. For 29 df $t_{.05}=1.70$ and $t_{.01}=2.46$ (one-tailed)

2. For 22 df $t_{.05}=1.72$ and $t_{.01}=2.51$ (one-tailed)

3. For 12 df $t_{.05}=2.78$ and $t_{.01}=2.68$ (one-tailed)

4. Study I - Problem-solvers n=6 and Non-solvers n=25 (one immediate solver and one who refused to carry on not included)
Study II - Problem-solvers n=8 and Non-solvers n=16 (one immediate solver not included)
Study III- Problem-solvers n=4 and Non-solvers n=10

The bodily movements of the subjects were also found to show some differences in the first study. More systematic observations in the second and third studies of the motor level revealed some interesting trends. Generally the solvers retained a standing position more frequently than the non-solvers. Furthermore, they changed from a standing to a sitting (on the knees) posture much more quickly, thereby reflecting a "bodily" flexibility to go with the experimenting and manipulative approach. The non-solvers were more frequently either on their knees or squatting and they showed less flexibility in terms of changing their bodily posture. The subjects with extremely low activity level sat on their haunches and remained in that position for periods of up to 2 minutes. Further work is needed to study this aspect of problem solving. These studies should have more standardized conditions.

The personality inventory (OAP) and problem solving

The personality inventory did not show any significant correlations with the Hatrack problem. Similar non-significant results with other measures of personality have also been reported by Burke & Maier (1965). Raaheim and Kaufmann (1972) have shown some positive results with a measure of achievement motivation.

Because of the lack of any significant relationships, the OAP was excluded in studies II and III

Table 2

The Gestalt Completion Test (GCT) and problem solving

The GCT variables do not show any significant differences between the solvers and the non-solvers. The main trend in all the three studies are differences with respect to the regressive responses. Of the total number of solvers (20 subjects) only 5 had regressive responses, i.e. 25%, while 57% of the total number of non-solvers (51 subjects) had regressive responses. A four-fold table with these figures yields a Fisher's exact P, one-tailed, of 0.05. The Spearman correlations between level of non C-clamp activity and regressive responses (study I : 0.26, study II : 0.20, and study III : 0.44) are positive and in the expected direction. The general

Table 2. Comparisons between problem-solvers and non-solvers on the GCT-variables.

		Problem-solvers		Non-solvers		diff	t-value
		m	s	m	s	mean	
Stimulus bound	Study I	9.57	4.15	7.57	3.84	1.99	1.20
	Study II	10.11	5.13	8.68	4.51	1.42	0.72
	Study III	8.00	3.67	7.20	5.06	0.80	0.27
Fluency	Study I	11.86	7.58	10.73	5.60	1.13	0.44
	Study II	8.56	3.28	9.25	4.31	-0.69	0.42
	Study III	11.75	7.89	12.80	9.61	-0.95	0.18
Regression							
	Study I	0.28	0.49	1.28	1.75	-0.99	1.48
	Study II	0.33	0.70	0.62	0.71	-0.29	0.98
	Study III	0.50	0.87	3.60	3.01	-3.10	1.88
1-point responses							
	Study I	2.14	1.22	1.84	1.31	0.30	0.55
	Study II	1.11	1.76	1.87	1.99	-0.76	0.96
	Study III	2.00	1.23	1.70	1.95	0.30	0.27
2-point responses							
	Study I	4.00	1.63	2.44	2.00	1.56	1.89
	Study II	2.00	1.73	1.37	1.58	0.63	0.92
	Study III	4.50	-3.28	2.80	2.71	1.79	0.92
3-point responses							
	Study I	3.86	3.34	3.24	3.11	0.62	0.46
	Study II	7.00	4.50	5.31	3.63	1.69	1.03
	Study III	1.50	1.50	2.70	3.66	-1.20	0.59

- Note 1. For 30 df $t_{.05}=1.70$ and $t_{.01}=2.46$ (one-tailed)
2. For 23 df $t_{.05}=1.71$ and $t_{.01}=2.50$ (one-tailed)
3. For 12 df $t_{.05}=2.78$ and $t_{.01}=2.68$ (one-tailed)
4. Study I - Problem-solvers n=7 and Non-solvers n=25
Study II - Problem-solvers n=9 and Non-solvers n=16
Study III - Problem-solvers n=4 and Non-solvers n=10

conclusion, a tentative one, is that the level of activity without the clamp is more characteristic of subjects who: a) can not solve the problem, b) leave the stimulus (GCT) or the problem situation and the elements therein to be retained, and c) regress to modes of functioning that are maladaptive (Maini, 1973).

Another major trend characteristic of the solvers is having 2-point responses on the GCT. This trend is consistent in all the three studies. The two-point responses reflect the ability of the subjects to partially leave the GCT stimulus motif but still manage to form a whole gestalt, i.e. they manage to retain a balance between the two extremes of a continuum (Jern & Maini, 1971) - stimulus bound (3-point responses) and stimulus free (0-point responses). Smith and Danielsson (1978), in a study with scientists and humanists found that researchers rich in ideas could explore their imagination with awe without losing contact with reality, i.e. they could entertain both subjective and objective levels at the same time.

The Research Process interview and Problem Solving

As will be recalled, one of the aims of the interview was to let the researchers describe the similarities between the Hatrack problem and phases of research. Nine of the fourteen subjects in study III could see an immediate similarity. Three subjects could find some similarities after reflecting on the matter. Two of the subjects saw no similarities at all.

The 9 subjects exemplified the similarities by referring to experimental work in the laboratory, problems needing innovations while gathering data in the field, so called "Aha!" experiences and construction of apparatus. The following example summarizes the gist of the matter, "while in the field there arises a problem with the construction of a measuring apparatus I often get ideas and materials from a toy-shop and apply them in my research".

The 2 subjects who saw no similarities viewed their research as systematic attempts at gathering data and then describing it through categorization.

Stimulating moments in research work were varied and consisted of: an off-print, seeing the results, freedom in research, meeting people during research work, problem formulation, constructing an apparatus, etc. Moments that were described as tedious or boring were equally varied and consisted of writing out the final report for publication, data-gathering, working alone, monotony during certain unspecified phases, etc.

Seven of the researchers could describe and give examples of the emergence of ideas in research. The rest had difficulties in recapitulating such processes. One of the reasons given was that they considered their research as descriptive, and the mapping of a certain territory where there was not much room for creativity.

Some interesting differences emerged when a comparison was carried out between the solvers and the non-solvers with respect to the moments described above. All 4 of the solvers referred to the data-gathering stage as tedious and boring, while only one of the 10 non-solvers mentioned this (A four-fold table with these figures yields a Fisher's exact P , one-tailed, of 0.005). The 4 solvers found the results' part as the most interesting, while only 3 of the non-solvers name this stage specifically (Fisher's exact $P = 0.035$, one-tailed). Three of the solvers could describe situations relating to the emergence of ideas in their research work and 3 of the non-solvers could do the same. This could be due to the experimental set-up.

D i s c u s s i o n

The present studies further corroborate the findings of Raaheim and others as to the crucial role of the amount of stimulus-oriented activity indulged in by the problem solvers. This type of activity is lower among the non-solvers but instead these subjects show a type of activity that further distinguishes them from the solvers. The non-solvers are not as active as the solvers and they more frequently indulged in "thinking" without any concomitant manipulative, observable, activity. And when they did embark on an observable activity then the C-clamp was not included in their endeavours, as was the case with the solvers. It seems that the four elements (the two sticks, the cross on the floor, and the clamp) are not so easily manipulated by the non-solvers, who generally left out one of the elements, mostly the clamp. An interesting series of observations after the first study was the bodily position (motor level) of the subjects. This was brought to my notice by the non-solvers. They crouched, sat on their haunches etc., more frequently than the solvers. Among the non-solvers, who gradually seemed to give up, were those who sat on the floor and remained seated for relatively long periods of time. The solvers were manipulative and experimenting and whenever they crouched or sat on their knees, they did not remain in that position for long. On the contrary they showed a "bodily

flexibility" that was lacking in the non-solvers.

Among the non-solvers, the hierarchically organized conceptual and senso-motoric (more primitive) systems seem to undergo a regression and this is expressed in the postural activities of the subjects. It seems that the conceptual level often loses control and is unable to initiate facilitative behaviour. This could be termed an "irreversible regression" (cf. Nilsson, 1980). That the non-solvers were more regressive at a cognitive level is also seen in the stereotyped responses on the GCT. This result, though not reaching significance, does give some support to the above line of reasoning.

Bearing in mind autobiographical reports (Maini, 1971) about the role of motor activity during the emergence of ideas, it is possible that the Hatrack problem can help us to illuminate the role of the body (and the related motor activity) in the problem solving process, i.e. regression to the senso-motoric functioning in certain types of problems of a "reversible" and adaptive type. Szekely (1976), reporting upon the creative spells of a young scientist, attaches a special significance to the role of bodily states in the actual genesis of intuition.

In the third study, with the researchers, the aim was to find a "problem" for use in the laboratory that was in some way similar to phases in the research process. It seems appropriate to conclude that the Hatrack problem does help in shedding some light on the problem solving processes in research. This is most true for the empirical phases: apparatus construction, practical field problems while gathering data, and experimental laboratory work. Furthermore, the problem is sufficiently stimulating, not only for students but also for researchers.

The C-clamp activity level is reminiscent of the problems encountered in research and certain differences could be noted between the successful and unsuccessful problem solving researchers. The various intellectual challenges that the solvers

manage to master reflect not only the assimilatory (common to both groups) but also the accommodatory restructuring activity that is noted not only in the hatrack problem but also in the interview reports about the emergence of ideas, stimulating moments in research and the impatience to see the results of a certain investigation.

The above differences are only tentative and need further validation; a speculation would be that the solvers have a stronger desire for variety and that they are impatient to see the results in their research. The same desire for variety is reflected in the C-clamp activity level and mastery of the Hatrack problem. While most of the non-solvers are systematic who follow certain definite procedures, i.e. have accepted a research model of a systematic collection of data as dictated by the discipline and their personal past experiences, the solvers are more innovative and prepared to transgress certain limits set by the discipline, and their personal past experiences. In the latter case the accommodatory process is successful while for the former assimilation is the dominant process while working within a traditional model of the discipline.

I am grateful to FK S Hagstadius who helped in collecting the data for study II.

The research was supported by grants from the former Swedish Council for Social Science Research.

References

- Burke, R.J. & Maier, N.R.F. Attempts to predict success on an insight problem. Psychological Reports, 1965, 17, 303-310.
- Burke, R.J., Maier, N.R.F. & Hoffman, L.R. Functions of hints in individual problem-solving. American Journal of Psychology, 1966, 78, 389-399.
- Guilford, J.P. The Nature of Human Intelligence. New York: McGraw Hill, 1967.
- Jern, S. & Maini, S.M. An interpretation of utility Gestalt completion & personality variables on the continuum of objectivity-subjectivity. Psychological Research Bulletin, Lund University, 1971, 11, No. 12.
- Kragh, U. & Smith, G.J.W. Forming new patterns of experience. Psychological Research Bulletin, Lund University, 1974, 14, No. 6.
- Maier, N.R.F. & Burke, R.J. Test of the concept of "availability of functions" in problem solving. Psychological Reports, 1966, 19, 119-125.
- Maini, S.M. Creative and critical moments as reported by a group of "Scientists at Work", 1971, Lund: Department of Psychology (mimeo).
- Maini, S.M. Personality and cognitive differences between an original and non-original group. Perceptual and Motor Skills, 1973, 37, 555-563.
- Maini, S.M. & Nordbeck, B. Critical moments in research work. A study of research workers in the behavioural sciences. Psychological Research Bulletin, 1972, Lund University, 12, No. 10.
- Maini, S.M. & Nordbeck, B. Critical moments, the creative process and research motivation. International Social Science Journal, 1973, XXV, No. 1/2.
- Nilsson, A. The mechanisms of defence within a genetic-hierarchical frame of reference. Towards a synthesis of organismic and psycho-analytic theories, 1980, Lund: Department of Applied Psychology.
- Nordbeck, B. & Maini, S.M. Psychology of the researcher and research: critical moments and processes in research work. Project progress report - Part I. Psychological Research Bulletin, 1970, Lund University, 10, No. 11.

- Nordbeck, B. & Maini, S.M. Psychology of the researcher and research: Studies in the selection of potential researchers. Project progress report - Part II. Psychological Research Bulletin, 1970, Lund University, 10, No. 12
- Nordbeck, B. Problem - what is a problem? International Associations, 1971, No. 7.
- Nordbeck, B. Critical factors in research work. Factors influencing the individual's research process with special reference to biological research work. The Committee on Research Economics, 1975, Stockholm. No. 7.
- Raaheim, K. Problem solving and intelligence. Oslo: Universitetsforlaget, 1974.
- Raaheim, K. & Kaufmann, G. Need achievement and level of activity in an unfamiliar situation. Reports from the Institute of Psychology, 1977, University of Bergen, No. 2.
- Smith, G.J.W. & Danielsson, A. Richness in ideas, ego-involvement and efficiency in a group of scientists and humanists. A study of creativity using a process-oriented technique. Psychological Research Bulletin, 1978, Lund University, 18, No. 4-5.
- Szekely, L. Denkverlauf, Einsamkeit und Angst. Bern: Huber. 1976.

STUDIA PSYCHOLOGICA ET PAEDAGOGICA

SERIES ALTERA

1. Edlund, Sven: Diskussionen om begåvningsurvalet under reformations- och stormaktstiden. I. 1947.
2. Agrell, Jan: Nyinrättade professurer inom filosofiska fakulteten i Lund under 1800-talets första hälft. 1949.
3. Smith, Gudmund: Psychological Studies in Twin Differences. 1949.
4. Husén, Torsten: Om innebörden av psykologiska mätningar. 1949.
5. Smith, Gudmund: Interpretations of Behaviour Sequences. 1952.
6. Johannesson, Ingvar: Studier av sociala relationer mellan barn i folkskoleklasser. 1954.
7. Kragh, Ulf: The Actual-Genetic Model of Perception-Personality. 1955.
8. Bjerstedt, Åke: Interpretations of Sociometric Choice Status. 1956.
9. Werdelin, Ingvar: The Mathematical Ability. Experimental and Factorial Studies. 1958.
10. Werdelin, Ingvar: Geometrical Ability and the Space Factors in Boys and Girls. 1961.
11. Borg, Gunnar A. V.: Physical Performance and Perceived Exertion. 1962.
12. Lindell, Ebbe: Den svenska rättskrivningsmetodiken. 1964.
13. Bokander, Ingvar: Stereoscopically Induced Perceptual Conflict between Facial Photographs. 1968.
14. Bjerstedt, Åke: Twelve Years of Educational and Psychological Research in Sweden: A Bibliography. 1968.
15. Larsson, Bernt: Bayes Strategies and Human Information Seeking. 1968.
16. Bjerstedt, Åke: Educational Technology. Instructional Programming and Didakometry. 1972.
17. Löfgren, Horst: The Measurement of Language Proficiency. 1972.
18. Bierschenk, Bernhard: Självkonfrontation via intern television i lärarutbildningen. 1972.
19. Gestrelus, Kurt: Job Analysis and Determination of Training Needs. Examples of Methods Applied to Teacher Trainers. 1972.
20. Sjöbäck, Hans: The Psychoanalytic Theory of Defensive Processes. 1973.
21. Larsson, Inger: Individualized Mathematics Teaching. 1973.
22. Fredriksson, Lennart: The Use of Self-Observation and Questionnaires in Job Analysis for the Planning of Training. 1974.
23. Idman, Pekka: Equality and Democracy: Studies of Teacher Training. 1974.
24. Bjerstedt, Åke: Social Development and Training in School. 1974.
25. Alwall, Ellen: The Religious Trend in Secular English-Irish Schoolbooks 1850-1861 and 1871-1880. 1974.
26. Holmberg, Ingrid: Effects of Some Trials to Improve Mathematics Teaching. 1975.
27. Lindsten, Carin: Hembygdskunskap i årskurs 3. 1975.
28. Bjerstedt, Åke: Pedagogisk forskning i Sverige. En sexårsbibliografi. 1975.
29. Nordén, Kerstin: Psychological Studies of Deaf Adolescents. 1975.
30. Westerlundh, Bert: Aggression, Anxiety and Defence. 1976.
31. Jernryd, Elisabeth, "Optimal auktoritets- och propagandaresistens". 1976.
32. Bierschenk, Bernhard & Bierschenk, Inger: A System for a Computer-Based Content Analysis of Interview Data. 1976.
33. Wiechel, Lennart: Roller och rollspel. 1976.
34. Hedlund, Carl: Commissioned Army Officers. 1976.
35. Bergsten-Brucefors, Agneta: Intelligence Patterns and their Relation to Social Background. 1976.
36. Bjerstedt, Åke: Explorations in Creativity. 1976.
37. Wetterström, Magnhild: Medinflytande i skolan. 1977.
38. Bierschenk, Bernhard: Simulating Strategies of Interactive Behaviour. 1978.
39. Drakenberg, Margareth: Förändringar i prestationsprocessen. 1978.
40. Flinck, Rune: Correspondence Education Combined with Systematic Telephone Tutoring. 1978.
41. Norberg, Astrid: Uppfostran till underkastelse. 1978.
42. Eneskär, Barbro: Children's Language at Four and Six. 1978.
43. Eriksson, Mona: Utbildningspraktik. Om utbildning med handledda klient- och patientkontakter på högskolenivå. 1978.
44. Hagberg, Bo: Cognitive Impairment and Personality Change in Relation to Brain Dysfunction. 1978.

45. Leonardsson, Sigurd: Den franska grammatikens historia i Sverige. I. En översikt över perioden 1646–1866 och en antydan om den fortsatta utvecklingen. 1978.
46. Leonardsson, Sigurd: Histoire de la grammaire française en Suède. II. Analyse systématique et méthodologique. 1978.
47. Carlsson, Bertil: Två utbildningsprojekt. En redovisning av arbetet att profilera verksamheten vid en nystartad svensk högskola. 1979.
48. Lindholm, Lena-Pia: Pupil's Attitudes to Equality between the Sexes. 1980.
49. Maximilian, V. Alexander: Functional Changes in the Cortex during Mental Activation: Applications of rCBF Measurements in Neuropsychological Research. 1980.
50. Carlström, Inge: Law and Justice Education: A Survey of the Literature and Three Investigations – A Summary. 1980.
51. Prohovnik, Isak: Mapping Brainwork: Theoretical and Methodological Considerations in Applying the Regional CEREBRAL BLOOD FLOW Method to Neuropsychology. 1980.
52. Bååth, John A.: Postal Two-Way Communication in Correspondence Education. 1980.
53. Fritzell, Christer: Teaching, Science and Ideology. 1981.
54. Bjerstedt, Åke (Ed.) Swedish Educational Research in the Early Eighties. 1981.
55. S. M. Maini: Explorations in the Psychology of the Research Process. 1981.

